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Dioptrics. of the convex and concave surfaces of the lenses, and RE*r*, fig. 37, 38, or R*r*E, fig. 39, 40 are their axes. Taking any point A in one surface, draw RA, and parallel to this draw *ra*, which will cut the other surface of the lens in *a*. Join A*a*, and continue it till it meets the axis RER in same point E; this point E is called the centre of the lens, because every ray that passes through it will have its incident and emergent parts parallel, such as QA, and *qa*. From the similarity of the triangles REA, *r*E*a*, and the composition and division of ratios, we have RA$\mp$*ra* : *ra*=RE$\mp$*r*E (or R*r*) : *r*E, hence *r*E must be invariable like the other lines, and on whatever point the parallel radii RA, *ra*, are drawn, the line A*a* must cut the axis R*r* in the same point E. If we suppose the ray A*a* to pass out of the lens in both directions, it will suffer the same quantity of refraction in opposite directions, because the angles of incidence *a*AR, A*ar*, are equal. Hence the incident and emergent parts AQ, *aq*, will be parallel.

Fig. 39.

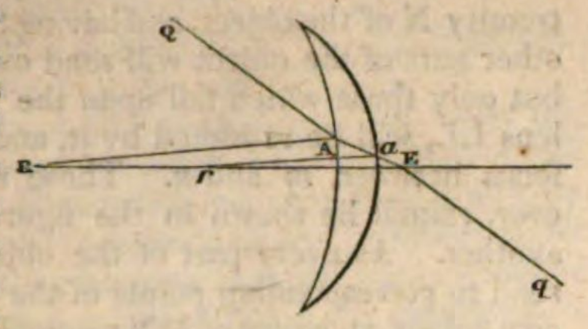
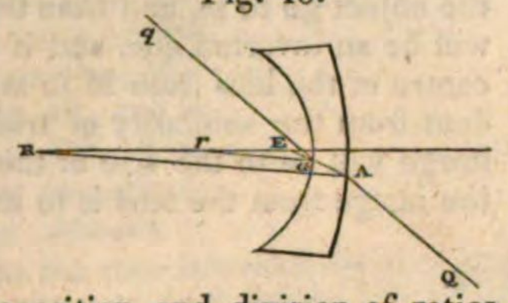


Fig. 40.



When the lens is small in diameter, or of a great focal length, or its thickness inconsiderable from other causes, the path of the ray QA*aq*, may be taken in a straight line passing through the centre E of the lenses. This is evident from the circumstance that the perpendicular distance between the lines AQ, *aq* diminishes both with the obliquity of the incident ray, and the thickness of the lens.

On the Refraction of Rays by Cylindrical Lenses.

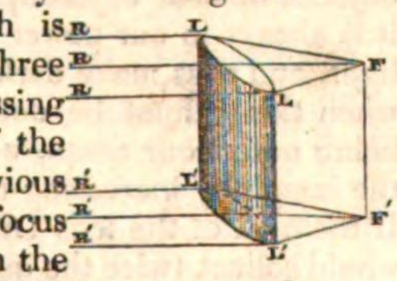
Refraction by cylindrical lenses. Cylindrical lenses may have all the forms of the lenses which we have already described. A perfect cylindrical lens corresponds with a sphere whose section is the same; a plano-convex cylinder has its section similar to a plano-convex lens of the same dimensions; and a meniscus cylinder has one of the cylindrical surfaces convex and another concave.

In all these cases the curved surfaces are cylindrical; that is, circular in one direction, and rectilineal in another; but we may combine a spherical surface either convex or concave, with a cylindrical surface either convex or concave, and thus produce cylindro-spherical lenses, an ingenious application of which to vision was made by Mr. Airy, for the purpose of remedying a defect in his own eye.

This class of lenses, therefore, whether entirely cylindrical, or cylindro-spherical, having been found of real use both in matters of science, and for the purposes of vision, it becomes of consequence to give a general account of their properties.

Let LLL′L′ be a double convex cylindrical lens, composed of two cylindrical surfaces, one of which is LLL′L′. Then if RRR be three parallel and horizontal rays passing through the thinnest portion of the upper part of the lens, it is obvious that they will be refracted to a focus at F, at the same distance from the lens, as in an ordinary lens. In like manner the rays R′R′R′ falling upon the lowest portion of the lens will have

Fig. 41.



Dioptrics. their focus at F′. Every intermediate portion of the lens will have a similar focus somewhere in the line FF′, and if we suppose all the rays to proceed from a distant object, such as the sun, there will be an image of the sun, or a luminous focus in every point of the line FF′, and FF′ will be a brilliant line of light. Dioptrics.

This property of a cylindrical lens to form a bright line of light has been ingeniously applied by Captain Kater in the construction of his azimuth compass, which we have described in our article MAGNETISM, vol. xiii. p. 765.

In cylindrical lenses diverging and converging rays will have the same foci as in common and concave lenses of the same curvature; and therefore the rules for finding their foci are applicable also to them.

Cylindrical lenses have been recently applied by Sir David Brewster for improving the vision of objects that are rectilineal, such as the defective lines in the solar spectrum. When these lines are not visible, or are very imperfectly visible, on account of the imperfections of the telescope, the application of a cylindrical lens, either solid or fluid, renders them more visible when the axis of the cylinder or cylindrical surface is accurately perpendicular to the lines. A prism has a similar effect. Both of them act in filling up the irregularities of the edges of the line by a succession of images of other parts of the line. If we look, for example, at a screw nail, or a twisted or rough rope, through a prism or cylinder, whose length is perpendicular to the screw or rope, the edges of both will be as smooth as if they were polished cylinders.

A patent was taken out several years ago by a Parisian artist for a transverse cylindrical lens similar to that shewn in fig. 22 O; which differs from the cylindrical lens in fig. 41 in this, that the second cylindrical surface has the axis of the cylinder of which it is a part, perpendicular to the axis of the cylinder of which the first surface is a part. The effect of this combination is *exactly* equivalent to a plano-convex glass of the same radii of curvature, and therefore it does not possess any superior properties, as was believed by its inventor.

If we cross two cylindrical lenses, such as that in fig. 41, at right angles, we shall have all the effect of a double convex lens. Or if we cross two good test tubes filled with water or any other fluid, in the same manner, we shall also obtain a rude imitation of the effect of a spherical lens, which may answer for the common purposes of a microscope.

Mr. Airy's sphero-cylindrical spectacles. The application of a cylindro-spherical lens by Mr. Airy to the purpose of remedying imperfect vision in his own eye deserves to be more particularly noticed. He found that his eye refracted rays to a nearer or shorter focus in a vertical than in a horizontal plane,[1] so that his eye was completely useless. Hence he concluded that the curvature of his cornea was greater in a vertical than in a horizontal plane, and he ingeniously proposed to correct this defect by cylindrical refraction. As the eye was shortsighted, he required concave surfaces to correct the general defect of a too convex cornea. He therefore had a lens constructed, which was doubly concave, one of the surfaces being spherically concave, and the other cylindrically concave, and of such a curvature as to bring to the same point the vertical and horizontal foci of the cornea. An artist of the name of Fuller, at Ipswich, constructed for Mr. Airy lenses of the proper dimensions, which enabled him to read the smallest print at a considerable distance with his defective eye, as well as he could do with the other. He found that vision was most distinct when the cylindrical surface was turned from the eye, and he placed the lens as near the eye as possible. There is another application of cylindrical lenses which we believe has not hitherto been made. In

[1] This was the case also in Dr. Thomas Young's eye, but it did not injure his vision. *El. Nat. Phil.* vol. ii. pp. 578, 9.

Bayerische Staatsbibliothek München

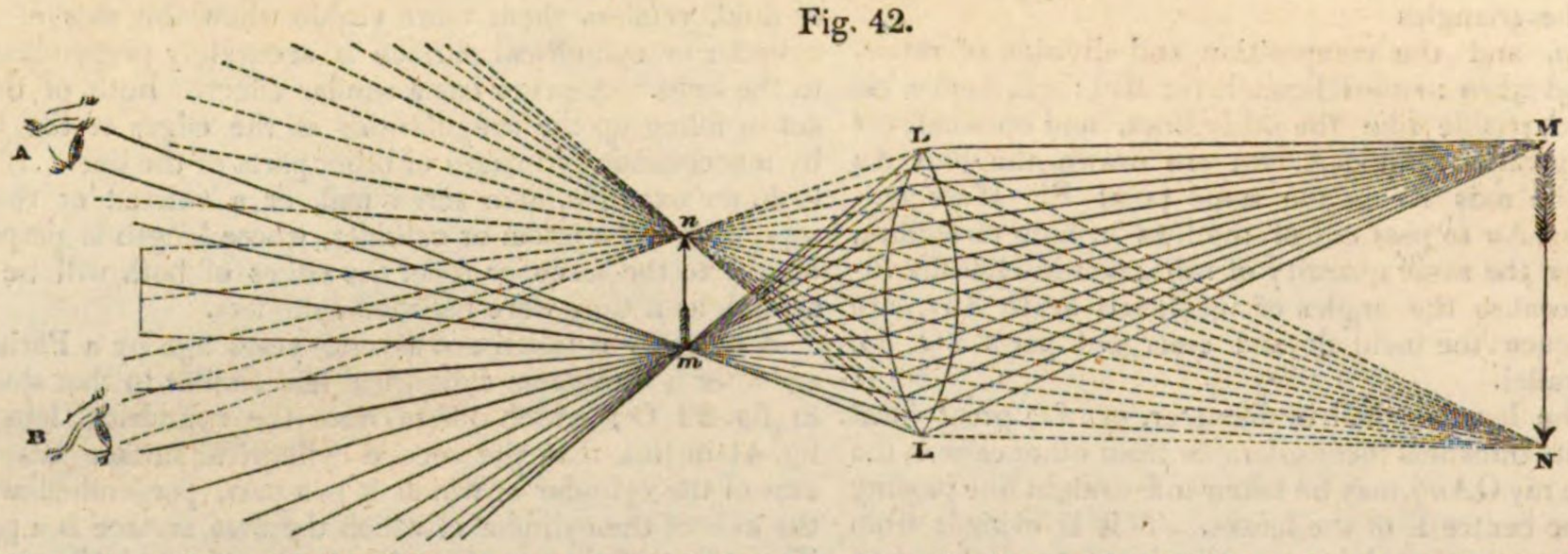
Dioptrics. all preparations of natural history, objects which are generally preserved in cylindrical bottles or vessels containing fluids, the objects are always seen distorted, being magnified to the greatest extent in a plane perpendicular to the length or axis of the cylinder, while in a rectangular direction, the object is not magnified at all. In order to see the objects of their true shape, and have them equally magnified in all directions, a cylindrical lens of a suitable focus should be employed, so that the axis of the cylinder may be at right angles to the cylindrical axis of the vessel.

SECT. III.—*On the Formation of Images by Lenses, and on the vision of objects through them.*

In the preceding section we have treated of the formation of images by rays transmitted through small apertures, and have considered the formation of images by reflecting surfaces.

In order to explain the formation of images by convex lenses, whether double, or plano-convex, or meniscuses, let LL be a convex lens, MN an object farther from it than its principal focus. Let MLL be a cone of divergent rays proceding from M, and having their focus at *m* behind the lens; and NLL another similar cone from the other extremity N of the object, and having their focus at *n*. Every other part of the object will send out rays in all directions; but only those which fall upon the circular surface of the lens LL, will be refracted by it, and they will all have their focus between *m* and *n*. These refracted pencils, however, cannot be shewn in the figure without crossing one another. As every part of the object MN, will therefore send to corresponding points of the image *mn* rays of their own colour, an image of MN resembling it in all respects will be formed at *mn*, and as the rays from the upper part M of the object go to *m*, and from the lower part to *n*, this image will be an inverted one, and if we draw lines through the centre of the lens from M to *m*, and N to *n*, it will be evident from the similarity of triangles that the size of the image will be to the size of the object, as the distance of the image from the lens is to the distance of the object. Dioptrics.

Fig. 42.



If we place the eye behind this image *mn*, we do not see it suspended in the air at *mn*, but it appears as if it were in front of the lens. That the image, however, is formed at *mn*, may be proved by viewing it on smoke raised at that place, or on a piece of ground glass, or semi-transparent paper; or if we bring the eye in front, we shall see it distinctly painted on any white ground, such as a piece of white paper. We shall suppose it, however, to be seen on smoke by the eye placed behind it at A or B. It will be seen exactly at *mn*, as if it were a real object; and in order to see it distinctly, the eye must view it at the same distance as it views other objects, and it may be viewed as any other object is, through a pair of spectacles or a magnifying glass.

As all the rays from M, N cross each other at the points *m*, *n* of the image, the very same rays radiate from those points that radiated from M, N, and consequently the very same effect must be produced in the eye as if these rays proceeded from a real object at *mn*. Hence by placing another convex lens at a proper distance behind *mn*, a distance greater than its principal focus, we may form another image of this image, in the conjugate focus of the second lens.

If we wish to form a magnified image of an object by any lens, we have only to place the object nearer the lens, and it follows from the rules for conjugate foci that the image will increase. If MN, for example, is brought nearer LL, the image *mn* will recede from the lens, and increase in size. When ML is equal to twice the principal focal distance of the lens, the distance of the image *m*L, and the size of the image will be the same as that of the object MN. If MN comes still nearer the lens, *mn* will recede still farther, and continue to increase in size till it becomes infinitely large and infinitely distant. When this happens, the rays which form it will have become parallel. If during all these changes the eye is withdrawn from the lens so as to be at least six inches behind the place where the image is formed, it will observe the image distinctly before it. But when the rays become parallel, the eye may then be placed immediately behind the lens, and it will see the object distinctly in the anterior principal focus of the lens, and magnified in proportion to the shortness of the focal distance of the lens.

In the preceding paragraphs, we have described the principles of the *camera obscura*, the *compound microscope*, and the operation of the *single microscope*. When the image *mn* is distinctly formed on paper, the lens LL acts as in the *camera obscura*, painting all objects before it in their natural colours, in their just proportions, and with all their movements, on a white ground placed behind it. When the image *mn* has become greater than the object MN, by the advance of the latter to the lens, the eye views this magnified picture, and the effect is the same as in the *compound microscope*, whose object-glass is LL, and whose eye-glass has a focal distance equal to that of the eye. When the image is infinitely distant, and the rays enter the eye parallel, the object being then in the anterior principal focus of the lens LL, and the eye behind it, the lens is then acting as a *single microscope*.

When objects are within our reach, such as microscopic objects, or near objects presented before a camera obscura, it is always in our power to illuminate them with artificial light, and thus make dark objects give brighter images; but when this cannot be done, in consequence of the objects being out of our reach, we can increase the brightness of the image by increasing the area or superficies of the lens. If the area of the lens LL, for example, were doubled, it would collect twice the quantity of rays that flow from every point of an object, and concentrate them at the corresponding points of the image *mn*.

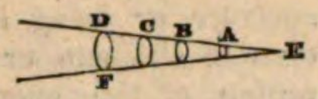
In order to understand the principle of the *telescope* and *single microscope*, we must be acquainted with what is

Dioptrics.

Apparent magnitude.

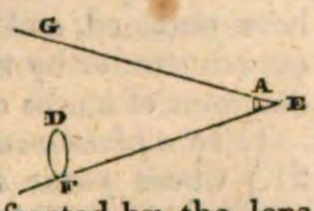
called the *apparent magnitudes* of objects. If we hold a sixpence A at the distance of six or eight inches from the eye E, then it will exactly cover or appear equal to a shilling placed at B, a half-crown placed at C, and a crown at D. If we remove the sixpence A, the shilling will just cover the half-crown. If we remove the shilling, the half-crown will just cover the crown. Hence all these coins placed as they are in the figure, are said to have to an eye placed at E the same apparent magnitude, because they are all seen under the same angle DEF, and would all cover the same portion of the sky, or of any distant object.

Fig. 43.



If the sixpence A is brought thrice as near the eye E as in fig. 44, its angle of apparent magnitude will now be GEF thrice as great as DEF, fig. 43, and it will appear thrice as large as DF. The sixpence has therefore been magnified; and if we interpose a lens between it and the eye, so as to make the rays refracted by the lens parallel, it will appear distinctly *magnified*, and the lens which we interpose will be a single microscope.

Fig. 44.



Magnifying power explained.

Objects within our reach, and capable of being placed where we please, may be therefore magnified to any extent, by placing them very near the eye, and in the anterior focus of a small convex glass, which, by making the diverging rays parallel, render the object as distinctly seen under a great angle, as if it were a large object placed at a distance, and subtending the same angle at the eye.

But when objects are at a distance, and beyond our reach, such as remote terrestrial objects, and the planets and stars, we can magnify them, or represent them to our eye under a greater angle of apparent magnitude, by a different principle. If the object is the dial-plate of a clock, at the distance of 12,000 feet, we place a lens whose focal distance is *six* feet, in the end of a tube about six feet long, and having directed it to the dial-plate, a distinct inverted image of the dial-plate will be formed in the focus of the lens, at a distance of six feet from it, and if we view this image with our eye placed six inches behind it, we shall see the image of the dial-plate distinct and magnified. Now, as the distance of the dial-plate is 12,000 feet, and that of the image only *six* feet from the lens, the image will be $\frac{12{,}000}{6}$, or 2000 times smaller in diameter than the object, not in apparent magnitude, but by real measurement; and if we were to take the image and place it beside the dial-plate, and view them both at the distance of 12,000 feet, their apparent magnitudes would, like their real magnitudes, be in the proportion of 2000 to 1. But the image is fortunately within our reach, and we can do with it what we choose. Let us first view it with the naked eye, which, generally speaking, sees objects most distinctly at a distance of six inches, and as we see it at the distance of six inches, it will appear as much greater as it would have done at the distance of 12,000 feet, as 12,000 feet is to six inches, or as 24,000 is to 1. Hence it follows, that though the image is diminished in the focus of the lens 2000 times, yet it is magnified from its proximity to the eye 24,000 times, that is, it is magnified on the whole $\frac{24{,}000}{2000}$, or *twelve* times. Now, this magnifying effect will be found under all circumstances to be equal to the focal length of the lens employed, divided by the focal distance of the eye, or the distance at which it sees small objects most distinctly, which is six inches, that is, in the present case $\frac{\text{six feet}}{\text{six inches}}$, or $\frac{72 \text{ inches}}{6 \text{ inches}}$, or *twelve* times. A short-sighted person, whose eyes have a focus of only three inches, would be able to see the same image of the dial-plate at the distance of *three* inches, and in his case the magnified effect would be $\frac{72 \text{ inches}}{3 \text{ inches}}$, or 24 times, and an old person, or one whose eyes were long-sighted, so as not to be able to see objects distinctly, nearer than 12 inches, would see the dial-plate magnified only six times. But both these persons could put on highly magnifying spectacles, so as to see the image at very short distances, or what is the same thing, to look at the image of the dial-plate through a magnifying glass, which would enable them to see it at the distance of one inch. In this case the magnifying effect would be $\frac{72}{1}$, or 72 times.

Dioptrics.

Telescopes

But the instrument which we have now fitted up is precisely a telescope, the large lens being its object-glass, and the small one used by the observer its eye-glass, and hence the magnifying power of such an instrument is always equal to the focal length of the object-glass divided by the focal length of the eye-glass. The image formed by such a telescope is inverted, which is of no consequence when we look at the heavenly bodies, and it is therefore called an *astronomical telescope;* but in looking at the dial-plate, and at terrestrial objects, the inversion would be disagreeable, and it is therefore usual to make the image erect, by using either a *concave* eye-glass, or three or more convex eye-glasses. In the former case it is called the *Galilean telescope*, and in the latter a *terrestrial telescope*.

When the distance of the object is not very great, or when the focal length of the lens bears a considerable proportion to the distance of the object, the magnifying power of a lens, when the eye views the image formed by the lens at the distance of six inches, is the following. Subtract the focal distance of the lens in feet from the distance between the image and the object, and divide the remainder by the same focal distance. By this quotient divide twice the distance of the object in feet, and the quotient will express the magnifying power, or the number of times that the object has been increased in apparent magnitude by the lens.

The very same observations apply to images formed by concave mirrors, and hence a single concave mirror becomes the simplest form of the reflecting telescope, the eye viewing the image which it forms. In the case of such images the body or the head of the observer must be placed between the object and the image, so that in order to use a single concave mirror, we must either make the mirror so large that the observer's head will not obstruct all the light, or we must make the reflexion a little obliquely, or, what is done in practice, we must by means of a small plane mirror or a prism reflect or refract the rays to one side, so as to allow the observer to look at the image formed by the concave mirror, without obstructing the rays in their passage from the object to the mirror, the quantity obstructed by the plane mirror or prism being too small to do any injury. If we view the image through a convex lens, so as to magnify it still more, the mirror and the lens will constitute a *reflecting telescope*.

PART III. ON SPHERICAL ABERRATION AND CAUSTIC CURVES.

Spherical aberration.

The rules which we have already given for finding the foci of lenses and mirrors, are strictly applicable only to rays that pass near the axis of the lenses and mirrors; and this may be readily proved by the method of finding the refracted and reflecting ray which we have explained and used.

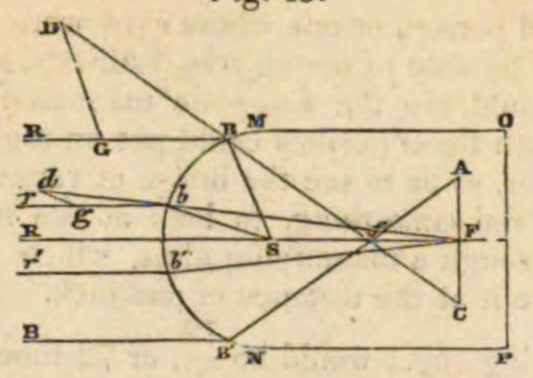
SECT I.—*On Spherical Aberration of Lenses.*

In order to prove and illustrate the preceding truth, we shall suppose parallel rays to be incident on a mass of glass MNOP, in which there is only refraction at its first surface, and we do this both to avoid the confusion of lines, and because it is perfectly sufficient for the purpose of explanation. Let RS be the axis of the spherical surface MN, passing

Spherical aberration.

through S, its centre of curvature; and if we consider it a ray, also, it will go on to F without any refraction. Let RB be a ray falling on the refracting surface at a distance from the axis RS, and parallel to it. From the point of incidence draw BS, which will be perpendicular to the surface at B, and take BG three fourths of BR, BG being to BR as 1 is to 1·500, the index of refraction. From G draw GD parallel to BS, and making BD equal to BR, through the points D and B, draw B*f*C for the refracted ray. Do the very same thing for the ray RB′ falling on the point B′, and parallel to RS, and equidistant from it, and B*f*A will be the refracted ray.

Fig. 45.



If we now take two rays *rb*, *r′b′* near the axis, and parallel to and equidistant from it, and apply the same method of projection to them, we shall find the refracted rays to be *b*F, *b′*F crossing the axis, and converging at a point F, more remote from the refracting surface than *f*. If we draw through F a line AEC, perpendicular to the axis, then A and C being the points where the marginal or most remote rays which fall on the surface MN, and F being the focus of those nearest the axis, the distance *f*F is called the *longitudinal spherical aberration*, and AC the *lateral spherical aberration* of the lens.

These results may be obtained experimentally by covering up with a circle of black paper, all the central parts of the spherical surface, leaving a clear marginal ring corresponding with BB′. If the surface thus limited is exposed to the solar rays, we shall find a pretty distinct picture or image of the sun formed at *f*, which, from a cause which we shall soon explain, will be highly coloured at the edges. If we now remove the black circle from the surface MN, and cover the outside surface with black paper, excepting a small opening in the vertex of the lens, where the axis RS cuts it, and expose the lens to the sun's rays, we shall find the image of the sun distinct at F, and it will be less coloured than the image formed at *f* from another cause.

If we now expose successive rings of the surface MN to the sun's light, shutting up all the rest of the lens, we shall find that the ring nearest the axis will have its focus near *f*, between *f* and F; the second ring, its focus still nearer F; the third, its focus still nearer F; and so on, till the last ring will give its image of the sun close to F. Hence it follows, that there will be distinct images of the sun formed by each ring, and occupying the whole space *f*F; and, therefore, if we expose the whole surface MN to the solar rays, the image of the sun must be extremely confused and indistinct; and if received upon a sheet of white paper placed at AC, it will consist of a bright disc at F, surrounded with a broad halo of light, becoming fainter and fainter towards A and C.[1]

As this is true of every spherical surface whatever, it follows, that every image formed by a spherical surface or lens, and every object seen through it, must be indistinct, from the confusion of rays produced by spherical aberration. As this indistinctness increases with the aperture of the lens, or the distance of the marginal rays from the axis, we may remove it to a certain degree by limiting the aperture, or using smaller lenses; but excepting in the case of the sun or any highly luminous body, this diminution of the aperture would injure vision, from the want of light, especially in microscopes and telescopes; and hence it becomes an object of the highest importance in optics, and it is one which has occupied much attention, to discover methods of diminishing or correcting the spherical aberration of lenses. Spherical aberration.

Philosophers have, therefore, been led to calculate with accuracy the amount of spherical aberration in lenses of different forms, and having different sides exposed to the incident rays. The following are the results which they have obtained, and they may be readily verified either by experiment, or by tracing the refracted rays through large diagrams of lenses of different shapes.

Forms of lenses of least and greatest aberration.

1. In a *plano-convex* lens, (such as that shewn at E, fig. 21.) whose *plane side is turned to parallel rays*, or to distant objects, if it is intended to form an image of them in its focus; or with its plane side turned to the eye, if it is to be employed as a single microscope or magnifier, the *spherical aberration* is $4\frac{1}{2}$ *times its thickness*, or the *greatest* that can be obtained from it. This is called its *worst* position.

2. In a *plano-convex* lens, whose *convex side is turned to parallel rays*, the spherical aberration is only $1\frac{17}{100}$ths of its thickness, or the *least* that can be obtained from it. This is called its *best* position.

3. In *double convex lenses* with equal convexities, the spherical aberration is $1\frac{67}{1000}$ths of their thickness, greater than that of a plano-convex lens in its best position.

4. In *double convex lenses*, having their radii as 2 to 5, the spherical aberration will be the same as in a *plano-convex* lens in its *worst position*, if the flattest side, or that which has its radius 5, is turned towards parallel rays; and it will be the same as that of a *plano-convex lens* in its *best position*, if the surface whose radius is 2 is turned to parallel rays.

5. The *lens of least spherical aberration* is a double convex one, the radii of whose surfaces are as 1 to 6, having the surface whose radius is 1 *turned towards parallel rays*. In this, which is its best position, the aberration is only $1\frac{7}{100}$ths of its thickness. But if the side with the radius 6 is turned towards parallel rays, the aberration will be $3\frac{45}{100}$ths of its thickness.

If we determine the virtual focus of the central and marginal rays for a concave surface, as in fig. 45, we shall find that the spherical aberration is exactly the same for *concave* as for *convex* lenses; and hence, all the preceding results are equally applicable to them.

If we suppose that the lens of least spherical aberration, as in art. 5, has an aberration expressed by unity, the comparative aberrations of other lenses will be as follows:

Double convex or concave with radii as 1 to 6, in *best position*	1·000
Plano-convex or concave in *best position*	1·081
Double equi-convex or equi-concave	1·561
Plano-convex or concave in *worst position*	4·206

[1] "The effect of aberration," says Sir John Herschel, "may be very prettily exhibited by covering a large convex lens with a paper screen full of small round holes, regularly disposed, and exposing it to the sun, receiving the converged rays on a white paper behind the lens, which should be first placed very near it, and then gradually withdrawn. The pencils which passed through the holes will form spots on the screen, and their disposition will become more and more unequal over the surface, as the screen is farther removed; those at the circumference becoming crowded together before the central ones. The manner in which the several spots corresponding to central rays blend together into an image at the focus, and those formed by the exterior ones are scattered round it, gives us a very good idea of the variation of density of the rays in the circle of aberration at or near the principal focus; and if the white screen be waved rapidly to and fro in the cone of rays, so as to pass over the focus at each oscillation, the whole cone will be seen as a solid figure in the air, and the place of the circle of least aberration will become evident to the eye, forming altogether a very pleasing and instructive experiment." *Treatise on Light*, § 317.

Spherical aberration.

As a general rule for all lenses already made, and whose focus it is inconvenient to alter, the *most convex surface* should always be placed *towards parallel rays* when the lenses are used singly.

Aberration with different media.

The preceding results are calculated on the supposition, that the lens is made of glass, whose index of refraction is 1·500; but the numerical results vary greatly when we use transparent media of higher and lower refractive powers. When the index of refraction, for example, is 1·6861, which is nearly that of some of the metallic glasses, and of several precious stones, and of sulphuret of carbon nearly, the lens of *least spherical aberration*, is not one which has its radii as 1 to 6, but one which is *plano-convex;* and when we come to higher refractive powers, such as those of *sapphire*, *ruby*, *garnet* and *diamond*, of which lenses are now made for microscopes, and ought to be made for the eye-glasses of powerful telescopes, one of the surfaces of the lens of least spherical aberration must be concave. This will be seen from the following results which we have calculated from Sir John Herschel's Formula,[1] viz. $\frac{R''}{R'} = \frac{2\mu^2 - \mu - 4}{2\mu^2 + \mu}$ where R″ and R′ are the radii of the surfaces of the lens of least spherical aberration, and μ the index of refraction.[2]

	Index of Refraction.	Ratio.
Vacuum	1·000	1 to 1·00 equi-convex.
Tabasheer	1·100	1 to 1·31
New fluid in amethyst	1·111	1 to 1·35
Second do. in topaz	1·200	1 to 1·76
Ice	1·300	1 to 2·43
—— Water	1·3368	1 to 2·77
Cryolite	1·350	1 to 2·93
Fluor spar	1·400	1 to 3·60
Plate glass	1·500	1 to 6·00
Quartz, Topaz	1·600	1 to 14·00
Chrysolite	1·686	1 to infinity, plano-convex.
Sulphuret of carbon	1·700	1 to —93 meniscus.
Garnet, Ruby	1·800	1 to —12
Glass—lead 2½, flint 1	1·900	1 to —7
Zircon	2·000	1 to —5
Diamond, Octohedrite	2·500	1 to —2·5
Chromate of lead	3·000	1 to —2·1
	3·500	1 to —1·6
	4·000	1 to —1·5 equal radii.
	infinite	1 to —1

But it is not merely the curvature of the lens of least aberration that changes its character and its magnitude,—the aberration itself suffers a very great variation. This will appear from the table already referred to in our article MICROSCOPE; but we shall repeat that part of it which shews the amount of this change of the aberration, as the index of refraction changes from 1·4 to 2·0.

Index of refraction.	Spherical aberration when least in parts of the thickness of the lens, which is supposed 1.[3]
Fluor spar 1·4	1·096
Glass 1·5	1·071
Quartz 1·6	0·933
Epidote 1·7	0·666
Sapphire 1·8	0.357
Sulphate of Lead 1·9	0·166
Zircon 2·0	0·062

In the case of diamond the aberration must be next to nothing; but in order to obtain this great advantage, its second surface must be very concave, which diminishes greatly its magnifying power. We have no doubt that artificial glasses or other solids will yet be made by art, and that mineral bodies will be discovered which will have such a high refractive power, as to enable opticians to remove almost wholly the spherical aberration of single lenses.

Spherical aberration.

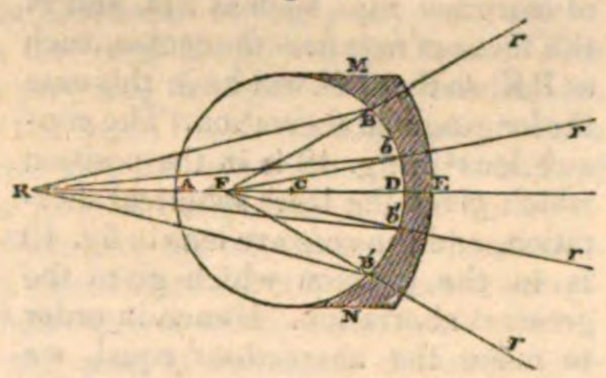
Hitherto we have spoken only of the aberration of parallel rays, the effect of which is invariably to shorten the focus of the marginal or exterior rays; but when the incident rays converge or diverge, the aberration diminishes, and the focus of the marginal rays continues to be nearer the surface than that of central rays, till the focus of convergence or divergence comes up to *two particular points in the axis*, at the first of which, as will be presently seen, the aberration disappears, and at the second of which, namely, the focus of parallel rays in the convex side, it is infinite. When the focus of convergence or divergence is situated between these points, the effect of aberration is to lengthen the focus of marginal rays, and shorten that of central rays, the focal distance of the latter being now shorter than that of the former. These results are true for all curvatures and all indices of refraction.[4]

Aberration of rays not parallel.

Sir John Herschel has given the following general rule for all double convex or concave lenses, and for all meniscuses and concavo-convex lenses in which the sum of the curvatures of their surfaces is greater than $\sqrt{2\mu + 3\mu^2}$ times their difference, (μ being their index of refraction.) *The effect of aberration will be to throw the focus of marginal rays more* TOWARDS the incident light *than that of central ones, when the lens is of a positive character, or makes parallel rays converge; but more* FROM *the incident light if of a negative character, or if it cause parallel rays to diverge.*[5]

We have mentioned above, that there is a point in the axis, at which rays which diverge from it, and fall upon a concave surface, will have no spherical aberration. This will be understood from fig. 46, where BB′ is the first concave surface of a medium, C its centre, RCD its axis, and A a point in the spherical surface, where it meets the axis beyond the centre C. If we take two points R, F, such that RC is equal to the radius AC of the surface multiplied by the index of refraction, or RA to AF as the index of refraction is to unity, then all rays diverging from R, whether marginal or central, and falling upon the concave surface BDB′, will be refracted at BB′ in directions B*r*, B′*r*, which will proceed from the virtual focus F without any spherical aberration. This may be readily proved by the projection of the rays. Hence if upon F as a centre with any radius FE greater than FD, we describe a circle MEN, we shall have the second surface of a concavo-convex lens, which will be entirely free of spherical aberration. This is evident, as the rays refracted by the first surface BDB′ fall perpendicularly on the second surface, and suffer therefore no refraction.

Fig. 46.



As there is a *concavo-convex lens* without aberration, for rays diverging from one point of its axis *r*, so there is a *meniscus* without aberration for rays converging to a particular point in its axis. Let RB, R′B′ be rays converging to a point *f* in the axis RC*f* of a convex refracting surface BDB′, whose centre is C. If we take *fc*, so that it is to the radius CD as the index of refraction is to unity, then it may be shewn by projection or calculation that the refracted rays RB, *rb*, whether marginal or central, will be refracted in lines BF, *bf* having the same focus F without any spherical aberration. Hence if with F as a centre we describe

[1] *Phil. Trans.*

[2] See our article MICROSCOPE for a table of the results obtained by Mr. Coddington, from indices of refraction from 1·4 up to 2·0.

[3] These aberrations are computed by Mr. Coddington.

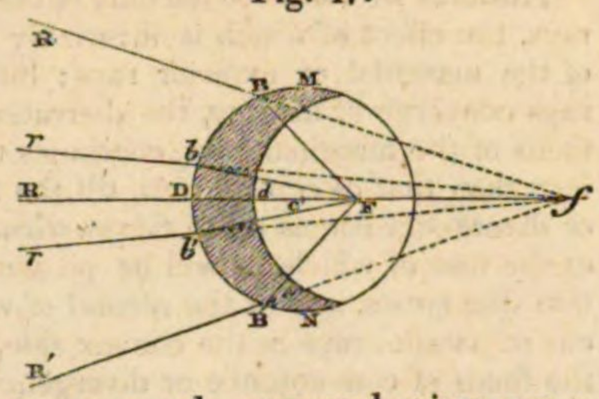
[4] Sir John Herschel's *Treatise on Light*, § 288.

[5] *Id.* 299.

Spherical aberration.

any circle, having its radius F*d* less than FD, we shall have the second or concave surface of a meniscus, which will have no aberration, because the rays BF, *b*F will pass through that surface perpendicularly, and suffer no refraction.

Fig. 47.



Owing to the injurious effect of spherical aberration on the performance of telescopes and compound microscopes, philosophers have sought to correct the spherical aberration of convex lenses, by the opposite aberration of concave ones. We have already given drawings[1] of three doublets without spherical aberration, according to the calculations of Sir John Herschel; and we shall now give an account of the method used by Dr. Blair of correcting the spherical aberration in his compound object-glasses, and as they possess some historical interest, we shall give the same diagrams which he employed. Let AB, fig. 48, represent a convex lens receiving a pencil of diverging rays from the object S, and let D be the focus of marginal and F that of rays incident near the axis, such as ST. The greatest longitudinal aberration will therefore in this case be DF. Let GH, fig. 49, be now a concave lens, upon which are incident parallel rays SHRK. Let P be the virtual focus of marginal rays, such as SH, and N the focus of rays near the centre, such as RK, so that PN will be in this case the longitudinal aberration. The convex lens in fig. 48 is in the position which gives the least spherical aberration, and the concave lens in fig. 49 is in the position which gives the greatest aberration. Hence in order to make the aberrations equal, we must make the focal distance of the convex glass much shorter than that of the concave one, and if it is requisite to have the distance of the points F and N from the convex and concave lenses the same as it is shewn in the figures, the object must then be placed much nearer the convex lens. Hence the image of the near object S is placed at the same distance from the convex lens in fig. 48, or the virtual focus of the concave lens in fig. 49, where it is shewn as refracting parallel or infinitely distant rays.

Fig. 48.

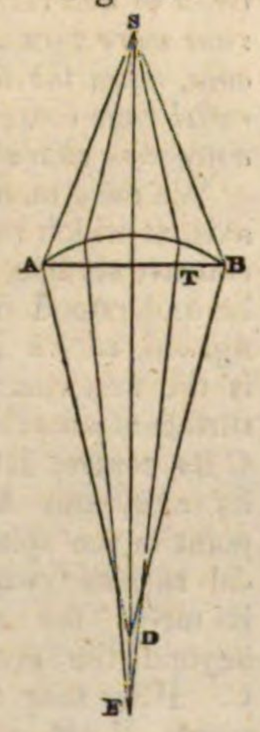
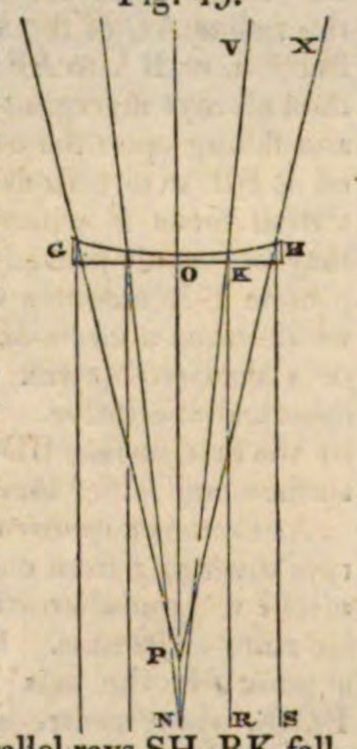


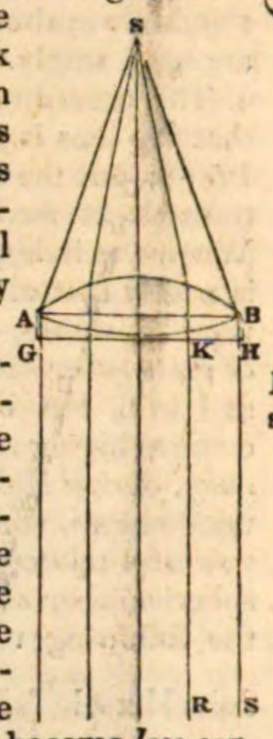
Fig. 49.



When the focal distance KN, therefore, for parallel rays is equal to the distance TF for rays diverging from S, and when the aberration DF and PN are equal, then if the two lenses are combined, as in fig. 50, parallel rays SH, RK falling upon them, will be refracted to the focus S, without any spherical aberration. For if we suppose all the rays from S, which the convex lens, fig. 48, converges to D and F, to be returned back from these points to the lens, they would be refracted accurately to S. But the parallel rays SH, RK, after refraction by the concave lens, fig. 49, in the directions HX, KV, are exactly in the same relative situation as the rays which we have supposed to be returned directly back from F and D are in at their incidence on the convex lens. Hence when these lenses are combined, as in fig. 50, parallel rays falling on the concave lens, and after refraction incident upon the convex lens, will be refracted accurately to S without any spherical aberration.[2]

Spherical aberration.

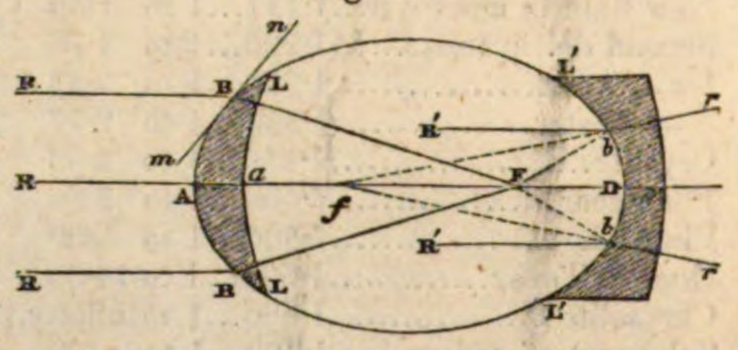
Fig. 50.



Lenses not spherical.

The difficulty of getting rid of the aberration of spherical surfaces, induced opticians at a very early period to propose the construction of lenses that were not spherical, and that had such forms as to be entirely free of spherical aberration. As the marginal parts of spherical lenses refract the rays which fall upon them too much, the spherical aberration would obviously be removed or diminished, by giving the surface any curvature, in which the marginal parts become *less convex*. Now, this is the character of two well known curves, viz. the ellipse and the hyperbola, which, as Descartes discovered, may be employed in the formation of lenses in the following manner:—

Fig. 51.



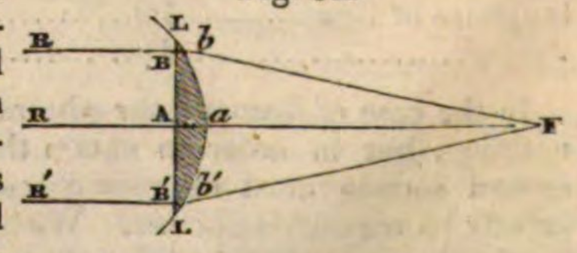
If a lens LL, fig. 51, has the form of a meniscus in which the convex surface LAL is part of a prolate spheroid formed by the revolution of an ellipse, whose greater axis AD is to its eccentricity or distance between its foci F, *f* as the index of refraction is to unity, and if the other surface L*a*L is concave, and part of a sphere whose centre is F, the remoter focus of the spheroid, then rays RB, RA, RB parallel to the axis RF of the spheroid or the ellipse will be refracted by the convex spheroidal surface alone to the remoter focus F, and as these rays fall perpendicularly upon the second surface L*a*L, they will suffer no change whatever by its action, and continue their progress to the focus F.

The same property belongs to a *concavo-convex* lens L′L′, whose anterior or concave surface is part of a prolate spheroid of the same dimensions as for the meniscus, and having its convex side of any radius. In this case, all rays R′*b*, R′*b* parallel to the axis and incident at *b*, *b*, will be made to diverge from the same virtual focus F, and will suffer no change of direction in passing out of the second or convex surface, as they all fall upon it perpendicularly.

These truths may be proved by the most elementary principles of the conic section, or by drawing a tangent *mn* to the elliptical surfaces at B, *b*, and determining the refracted rays by the method already described.

Upon the same principles a *plano-convex* lens may be constructed without spherical aberration, as shewn in fig. 52, provided its posterior surface L*a*L is part of a hyperboloid formed by the revolution of a hyperbola L*a*L, whose greater axis is to the distance between the foci as the index of refraction is to unity. Pa-

Fig. 52.



[1] Art. Microscope, vol. xv. pp. 34, 35.

[2] See *Edinburgh Transactions*, vol. iii. p. 27.

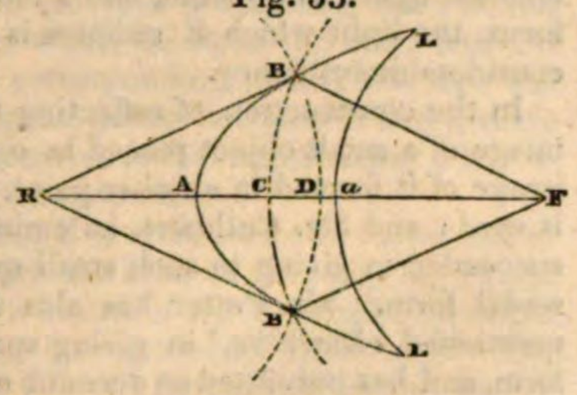
Spherical aberration.

rallel rays RB, RA, R′B′, will suffer no refraction at the plane surface BAB′, but at the points of the convex surface *b*, *b*′ will be refracted accurately to F, the further focus of the hyperboloid.

In like manner, a *plano-concave* lens having its concave surface part of a hyperboloid will diverge all rays so as to have their virtual focus in one of the foci of the hyperboloid.[1]

The following elegant method of determining the figure of a refracting surface which shall refract marginal and central rays to the same focus is due to Huygens. Let R be the focus of diverging rays, and F the focus to which it is required to refract them with accuracy. Take any point A as the vertex of the refracting surface required; the surface must be such that the incident and refracted rays RB, BF have such a ratio to each other, that the excess of RB above RA shall be to that of FA above FB, as the index of refraction is to unity. In order to find the curve BAB which possesses this property, take in the axis RF any point D, and let DA be divided at the point C in such a manner that AC is to AD as unity is to the index of refraction, and from R and F as centres, describe the arches of circles BDB′, BCB′, with the radii RD, FC, their points of intersection B, B′ will be in the required curve. In like manner, any other points in the curve may be found, and in order to convert it into a lens, we have only to describe a spherical surface L*a*L, round the focus F as a centre, so that the refracted rays BF, B′F may suffer no change by passing through it perpendicularly. The curve BAB gradually approaches to an ellipsoid as the radiant point R becomes more distant from the lens, and when it is infinitely distant, the curve is the section of an ellipsoid, whose further focus is in F.[2]

Fig. 53.



Various attempts have been made to execute lenses of other forms than spherical, but without decided success. Descartes has described machines for this purpose in the *tenth* chapter of his Dioptrics, but though he succeeded to a certain degree in his experiments, yet the art has never been acquired of producing figures sufficiently accurate for fine telescopes and microscopes.

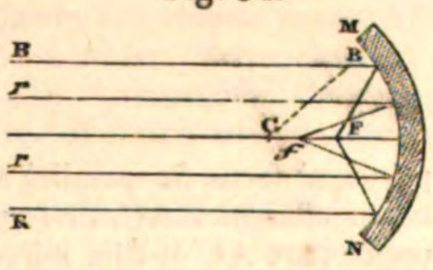
Sect. II.—*Spherical Aberration of Mirrors.*

Aberration of mirrors.

It has already been stated under *Catoptrics* in this article, that in all reflexions from spherical surfaces it is only for the ray near the axis that the rules for finding their foci are correct, those which fall farther and farther from the axis having their foci nearer the reflecting surface. Hence all the images which are formed by spherical surfaces are indistinct from spherical aberration, like those formed by lenses, with this difference, that the images are not confused with the different colours which always accompany the refraction of lenses.

If MN, fig. 54, is a concave mirror, by which parallel rays RR are reflected from its margin and *r*, *r*, from near its axis, it will be found from a simple projection of the reflected rays that R, R will invariably be reflected to a focus F nearer the mirror than the focus *f* of the central rays. The space F*f* is called the longitudinal or linear spherical aberration, and it will obviously become greater as the diameter of the mirror is increased, its focal length or its curvature remaining the same, and with its curvature when its diameter or aperture remains the same.

Fig. 54.



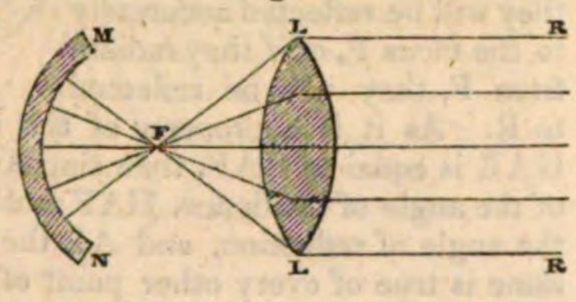
Spherical aberration.

In all cases but *one*, the marginal rays have a shorter focus than the central ones, or what is the same, have their focus nearest the reflecting surface. This case takes place when the radiant point is situated between the surface and the principal focus on the *concave* side of the mirror, in which case the focus of marginal rays is *farther from* the mirror than that of central rays.

There are only *two* cases in which spherical reflecting surfaces have *no* spherical aberration, namely, when diverging rays radiate from the centre of a concave mirror or spherical surface, in which case they are reflected back without aberration to the point from which they came, without any aberration, and when they converge to the centre of a convex mirror or spherical surface, in which case they will be reflected back in lines diverging from the centre or virtual focus behind it without any aberration.

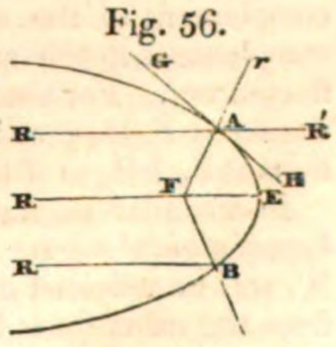
One of these cases, namely, the first, is not an ideal one, but is actually applicable to practical purposes. For example, if rays diverging from F the centre of curvature, (not the focus) of the reflecting mirror MN, fall upon the mirror, they will be reflected to F, and pass through F towards a lens LL, which will refract them into a parallel beam LLRR; if FL is the focal length of the lens, or into a converging beam, so as to illuminate strongly any near object, if FL is greater than the focal length of the lens. This contrivance has been proposed for light-house illumination, where, in addition to the beam FLL radiating directly from F the lens LL, receives also the other beam FMN, both of which it unites in one parallel beam LLRR. In the accurate illumination of objects for the microscope, this contrivance is also applicable; and hence for this purpose a *spherical* mirror is better than a mirror of any other form.

Fig. 55.



As we cannot in the case of reflectors diminish their spherical aberration as we did in lenses, by giving a different shape to the two surfaces, it becomes of great importance to form the reflecting surface in such a manner as to remove the spherical aberration altogether. It is evident from the inspection of fig. 54, where CB is a perpendicular to the mirror at B, RMC the angle of incidence, and CBF the angle of reflexion, that if the reflecting surface should be such that the line BF drawn to a fixed point, F should always form equal angles with a line CB perpendicular to the mirror at the point of incidence, the parallel rays would all converge to the point F. Now the *parabola* is a curve which possesses this property as shewn in fig. 56. Let AEB be a parabola which form a reflecting surface by its revolution round its axis RFE, and let R, R, R be parallel rays incident upon the paraboloidal surface at the points A, E, B. Then if F is the focus of the parabola, and GH a line touching the curve at A, it is a property of the parabola,[3] that the angle GAR is equal to HAF, but GAR is the complement of the angle of incidence, and therefore HAF will be the complement of the angle of reflexion, and

Fig. 56.



[1] See Descartes' *Dioptrica*, cap. viii.
[2] See Newton's *Lectiones Opticæ*, part i. sec. iv. and Huygen's *Traite de la Lumière*, p. 111, &c. &c.
[3] See Conic Sections, vol. vii. p. 222, prop. iii. cor. 3.

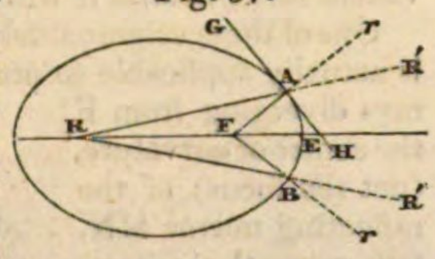
Spherical aberration.

consequently AF the reflected ray. As this is true for every ray parallel to the axis RFE, it follows that all parallel rays incident upon the surface of a paraboloidal mirror will be reflected accurately to the focus of the paraboloid.

It may be shewn, in like manner, that *convex paraboloidal reflectors* will reflect parallel rays, so as to make them diverge from the virtual focus of the paraboloid. If, in fig. 56, we continue the line RA to R, and also FA to *r*C, it follows, from the above reasoning, that R′AH is equal to *ra*C, and that the reflected ray is A*r*, diverging accurately from the focus F.

When we wish to reflect diverging rays to a focus, without aberration, we must have recourse to another solid of revolution, namely, a prolate spheroidal surface formed by the revolution of an ellipse round its greater axis. In this case, rays diverging from one of its foci will be reflected accurately, without aberration, to the focus F. This will be understood from fig. 57, where R, F are the foci of an ellipsoid, AEB a section of the ellipsoidal surface, and GH a line touching the ellipse at A; then if rays diverging from one of its foci R, fall upon the reflecting surface at A, E, and B, they will be reflected accurately to the focus F, or if they radiate from F, they will be reflected to R. As it is a property of the ellipse,[1] that the angle GAR is equal to HAF, then since GAR is the complement of the angle of incidence, HAF must be the complement of the angle of reflection, and AE the reflected ray. As the same is true of every other point of the ellipsoidal surface, it follows that all rays incident upon it from one focus, will be converged without aberration to the other focus.

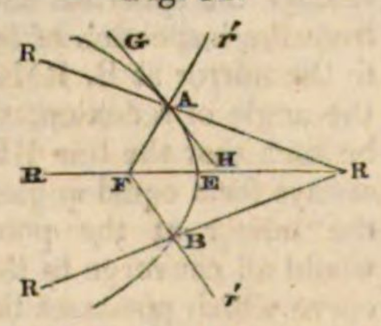
Fig. 57.



In like manner, it may be shewn, by producing RA to R′, and RB to R′, that rays falling upon a *convex ellipsoidal mirror*, and converging to one focus, will be reflected as if they diverged accurately from the other focus. That is, rays R′AR, R′BR, converging to R, will be reflected in diverging directions A*r*, B*r*, as if they diverged from the focus F, or rays *r*A, *r*B converging to F, will be reflected in directions AR′, BR′, as if they diverged from R as their virtual focus.

If the concave surface of a mirror is a portion of a *hyperboloid*, a solid generated by the revolution of a hyperbola about its axis, rays converging to one focus will be reflected to the other focus. Let AEB be a section of the hyperboloid, and RAR, RBR′, rays converging to its focus; these rays will be reflected to its other focus F. Let GH be a tangent to the hyperbola at A, then by a well-known property of the hyperbola,[2] the angle GAR is equal to HAF; but the former being the complement to the angle of incidence, and the latter the complement to the angle of reflection, AF will be the reflected ray. For the same reason, if the rays *diverge* from the focus F, they will, after reflexion, diverge in the directions AR, BR, as if they came from the other focus R′.

Fig. 58.



In a similar manner, it may be shewn, that in a *convex hyperboloidal mirror* AEB, rays diverging from one focus R′, will be reflected in directions A*r*, B*r*, as if they diverged from the other focus F.

The preceding truths are of great practical use in the construction of optical instruments. In all reflecting telescopes, where parallel rays are required to be reflected to a single focus, it is necessary that the figure of the reflecting surface should be that of a paraboloid; and as in the specula of such telescopes the portion of the paraboloid which is requisite, does not differ much from the same portion of a spherical surface that has the same focal length, artists have contrived particular methods by which the marginal parts of the spherical surface shall be worn down in the act of polishing, so as to convert the spherical into a paraboloidal surface. Caustics.

In the reflectors of light-houses, where a large surface is required to be used, a copper plate thickly plated with silver is hammered by means of a gauge to as correct a paraboloidal figure as possible, and a lamp being placed in its focus, the light which it radiates is reflected in a beam of considerable brilliancy.

In the construction of reflecting microscopes, where the image of a small object placed in one spot has a magnified image of it formed in another point, an ellipsoidal speculum is used; and Mr. Cuthbert, an eminent London artist, has succeeded in giving to such small specula an accurate ellipsoidal form. Mr. Potter has also succeeded, as we have mentioned elsewhere,[3] in giving specula a true ellipsoidal form, and has published an account of the method by which he was able to effect this important object.[4]

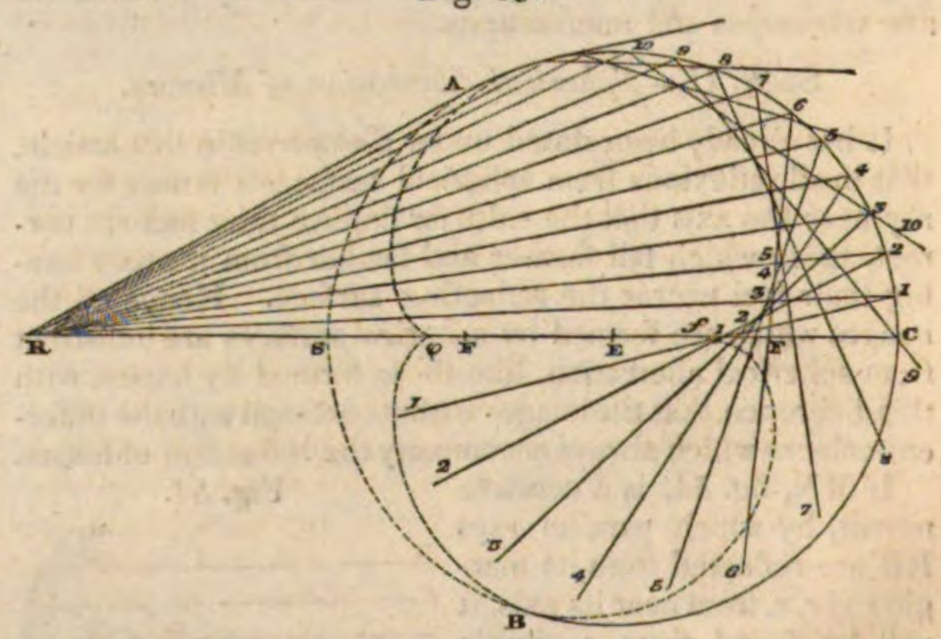
Sect. III.—*On Caustic Curves formed by Spherical Reflecting and Refracting Surfaces.*

Caustic curves.

When two or more rays of light cross one another at any point, they illuminate any reflecting substance placed in that point with their united light. Hence it follows, that when spherical surfaces converge the rays which fall upon them to different foci, these different foci must form so many illuminated points, if they are received on smoke, on white paper, or on water with any reflecting particles suspended in it. The lines which pass through these luminous foci, or rather the lines formed by the union of a great number of them, are called *caustics*, or *caustic curves*. As these curves are in reality a visible representation of the phenomena of spherical aberration, they possess considerable interest, as experimental illustrations of that class of facts.

When diverging rays fall upon a spherical mirror, whose surface exceeds a hemisphere, the caustics formed by reflexion are exceedingly beautiful. Let ACB be the section of such a spherical surface, whose centre is C, and whose principal focus for parallel and central rays is at *f*. Let a beam of light RAC, diverging from R, be incident on the upper part AC of this mirror, the beam consisting of the individual rays R1, R2, R3, &c., up to R10; and let the reflected rays 1, 1; 2, 2; 3, 3, &c., be found by making the angle of reflexion which they form with the perpendiculars

Fig. 59.



[1] See Conic Sections, vol. vii. p. 229, prop. v. cor. 4.
[2] Id. Id. p. 241, prop. v.
[3] Art. Microscope, vol. xv. p. 42.
[4] *Edin. Jour. of Science*, N. S., No. 12, p. 228.

Caustics. drawn from 1, 2, 3, &c., to C, equal to the angles of incidence which they form with the same perpendiculars. We shall then have the directions, and also the foci and intersections of all the rays. The ray 10, 10 does not meet the axis RC at all, but falling on the mirror at the point 3, will there suffer a second reflexion. The ray 9, 9 has its focus exactly at C, the vertex of the mirror, where it will suffer a second reflexion, and so on with all the rest, up to 14, which is the last which will suffer a second reflexion. All the reflected rays, after 9, 9, cross the axis, or have their foci at points gradually approaching to *f*, which is the focus of the central ray R 1. As all the rays proceeding from R, but not drawn in the figure, which fall upon the other half CB of the mirror, at points corresponding to R 1, R 2, &c., will have their foci in the same points between C and *f*, there will be along that line a series of foci constituting a line of light becoming more intense towards *f*.

But the rays R 10, R 9, R 8, cross each other after reflexion, and before they reach the axis, as shewn in the figure, and hence there will be a beautiful curve of light A*f*, called a *caustic*, formed by the intersection of these rays. The other half of the mirror CB will form a similar caustic, and the projecting points *f* are called the *cusps* of these caustics, and C*f* their tangent.

If a small pencil of light, consisting of two contiguous rays, moves from RA towards the position RB, being incident successively at 9, 8, 7, 6, &c., the conjugate focus of this pencil, or that formed by the intersection of the two rays of which it consists, will move along the caustic curve A*f*, while the points where it crosses the axis RC, or its focus formed by its union with a similar pencil similarly incident on the other half of the mirror, will advance from C to *f*.

If we now consider ACB as a *convex* spherical surface, and place the radiant point R as far to the right of the vertex C as it is to the left of it in the figure, and if we project the reflected rays, we shall find that when traced backwards, they will intersect the *axis* and each other, in the very same manner as they do in the figure, forming an *imaginary* or *virtual* caustic, in place of a *real* one, the two being in every respect the same.

If, while the radiant point R remains as in the figure, we suppose the convex surface ASB to receive the incident rays, it will then be found, by projecting the reflected rays, that they will form an imaginary caustic AφB, less than A*f*B, and joining it at the points A, B. This difference in size arises from the radiant point being in this case much nearer the convex surface than before.

Let us now suppose that the radiant point R recedes from the *concave* mirror ACB, the point *f* of the *cusps* will gradually approach to F, the tangent C*f* diminishing at the same time; and when R is infinitely distant, or the rays parallel, the point *f* will coincide with F, the focus of parallel rays. The same will take place in the case of the *convex* mirror ACB; but in the case of the convex mirror ASB, the point φ of the cusps will approach to F′, and will coincide with it when R is infinitely distant.

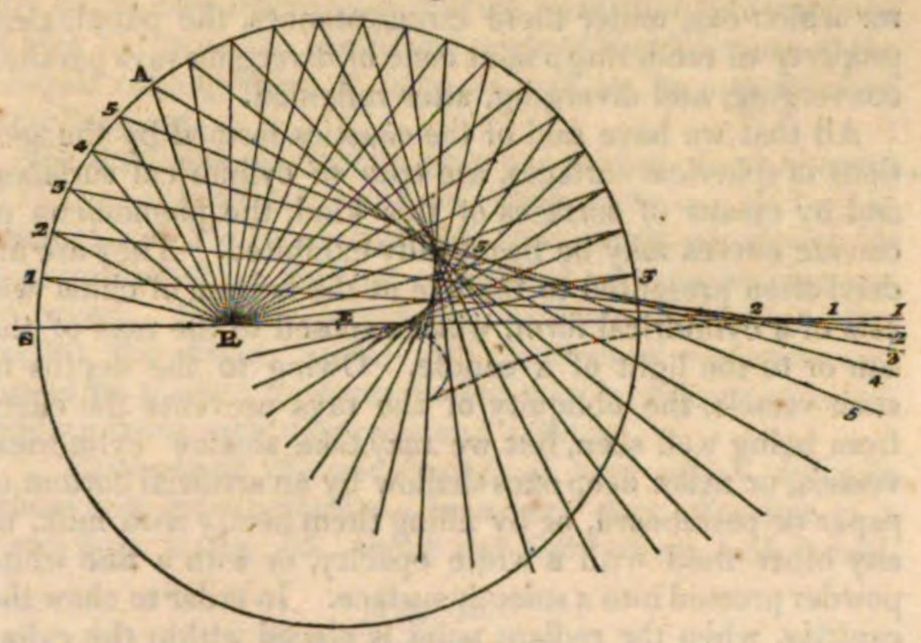
If, in the case of the *concave mirror* ACB, the radiant point R now approaches to the mirror, the cusps *f* will approach to the centre E of the mirror, the *caustic* curve A*f* becoming flatter and flatter, and when R reaches C, there will be no caustic at all, in consequence of all the rays being reflected back to the centre, all their *foci* and *intersections* having united in that point.

In the case of the *imaginary* caustic AφB, when R approaches to S, φ will also approach to S, the caustic approximating in form to the circular arch AS; and when R reaches S, φ will also reach S, the caustic disappearing when it has reached that limiting form. Caustics.

All that we have said is obviously applicable only to one section of the spherical mirror; but as the same is true of every section whatever, the caustic will not be a curve, but a surface formed by the revolution of the curves A*f*B round its axis *f*C, all the reflected rays being tangents to this surface.

We shall now consider the change in the appearance of the caustic, when the radiant point comes within the sphere of which the reflecting surface is a part, and when the mirror becomes a concave polished sphere. The effect thus produced is shewn in fig. 60, RE being less than RS′. In this case a remarkable double caustic will be formed, com-

Fig. 60.



posed of a short one of the kind shewn in fig. 59, and another with two long branches, one of which is shewn at 1, 2, 3, 4, 5, the dotted line below the axis SE shewing the other halves of the caustic, the long branches converging behind the mirror. Had R been placed nearer S than E, the branches 1, 2, 3, &c., would have diverged behind the mirror, having their virtual foci within the mirror. When R is half-way between S and E, the curved branches become parallel lines. When R comes nearer E the branches 1, 2, 3, &c., shorten; the smaller caustics also shorten; they both approach to the centre E, the long branches moving quickest till at E, as we have already seen, all the rays from R are reflected back to the same point, and the caustics all disappear.

M. A. Delarive, in his ingenious dissertation on caustic curves,[1] has shewn that caustics generated by parallel rays are *epicycloids*, formed by one circle rolling upon a fixed circle concentric with that of the mirror, and having a radius equal to half of its own. Dr. Smith has shewn that when the radiant point is at S, the caustic is an epicycloid, whose generating circle is two-thirds of the radius of the mirror, and the fixed circle one-third of that radius.[2]

When the radiant point passes the centre E, the caustics shift their place to the opposite side of E, and present the same phenomena as before.

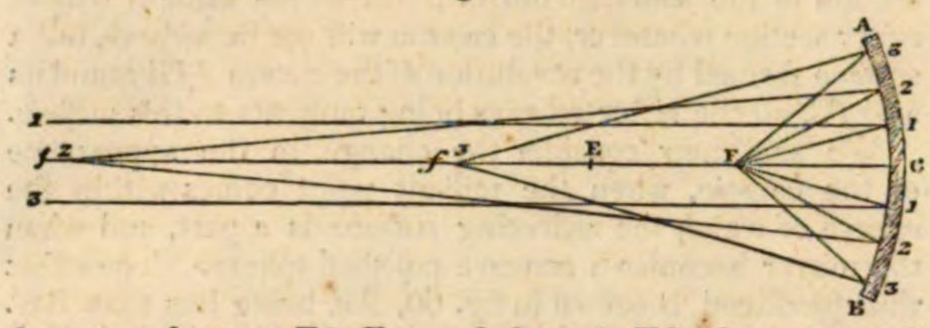
There is a curious property, however, involved in these phenomena, which we have represented in fig. 61, where the radiant point is supposed to be at F, a very little within the principal focus of a spherical mirror ACB. We have supposed the rays to diverge from a point *a little* within the principal focus, because it is only in this case that the rays F 1, F 1, at *a little* distance from the axis, may be reflected in directions 1, 1, 1, 1, exactly parallel. The rays F 2, F 2, falling at a greater distance from the axis, will be made to converge to a focus at *f* 2,

[1] *Dissertation sur la Partie de l'Optique qui traite des courbes dites Caustiques*, p. 84. Geneve, 1823. This interesting dissertation contains an account of the labours of preceding mathematicians, including Malus and Gergonne, and merits the attention of those who wish to prosecute the subject mathematically.

[2] *Complete System of Optics*, vol. i. p. 174.

Caustics. and rays F3, F3, to a focus *f* 3, still nearer the mirror. If we now conceive rays flowing from F to fall on the mirror

Fig. 61.



between the rays F 1, F 1, and the axis FC, these rays will diverge, because they radiate from a point a little within the principal focus, and hence we have one spherical mirror which has, under these circumstances, the paradoxical property of rendering a faint cone of diverging rays parallel, converging, and diverging, after reflexion.

Caustics from cylindrical surfaces.

All that we have said of the caustics formed by the sections of spherical surfaces, are true of cylindrical surfaces, and by means of surfaces of this kind, the phenomena of caustic curves may be beautifully exhibited. They are indeed often presented to the eye at the bottom of china vessels of a cylindrical form, when exposed to the rays of the sun or to the light of a candle. Owing to the depths of such vessels, the obliquity of the rays prevents the effect from being well seen, but we may take shallow cylindrical vessels, or make deep ones shallow by an artificial bottom of paper or pasteboard, or by filling them nearly with milk, or any other fluid with a white opacity, or with a fine white powder pressed into a smooth surface. In order to shew the caustics, when the radiant point is placed within the cylindrical surface, a piece of card should be made to float upon oil in the cylindrical vessel, and a very minute wick inserted in the card at the points of the axis where we wish the radiant point to be placed. This wick, when lighted, will be the radiant point R in fig. 60, and the caustics will be beautifully formed on the surface of the white card.

The following method, however, of exhibiting caustic curves, we have found very convenient and instructive, and it has the advantage of allowing the radiant point to come within the cylinder. A piece of steel-spring highly polished, such as a watch-spring, is bent into a concave form, like AB, fig. 62, and is placed vertically with its lower edge resting upon a piece of card or white paper. It is then exposed to the solar rays, or those of any artificial light, so that the plane of the card MN passes through the luminous body, and the caustic curves will be seen finely displayed, varying with the distance of the radiant point, and with the reflecting arch AB. By altering too the curvature of the arch and bending it into different known curves, either by applying a portion of its breadth to the required curves delineated upon a piece of wood, and either cut or burned sufficiently deep in the wood to allow the edge of the thin strip of metal to be inserted in it, a great variety of interesting phenomena may be observed. The brightest reflector is a thin strip of polished silver or plated copper. Gold and silver foil will also answer, or a strip of mica. A cylindrical section of a wide glass tube or a bottle, especially if a piece is cut out of them to allow the incident rays to pass to the reflecting surface in the plane nearly of the base of the cylinder, will produce the caustic curves in great perfection. The caustic curves produced by a highly gilt or polished metallic ring, such as the ring of a bell handle, are exceedingly beautiful, the phenomena of a convex and a concave surface being here united.

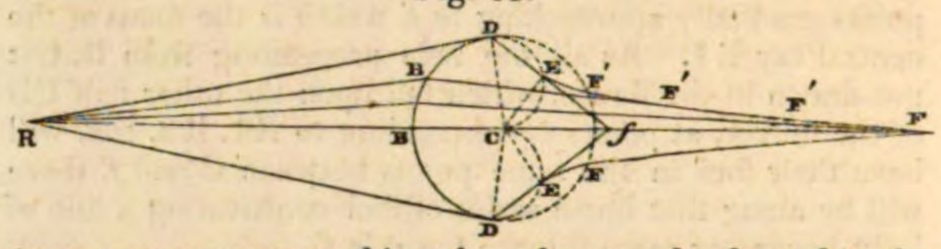
Fig. 62.

Caustics formed by Refracting Surfaces.

Caustics.

It is evident, from what has been said of caustics formed by reflexion or *Catacaustics*, that analogous curves must also be formed by spherical refracting surfaces, which has been called *Diacaustics*. In order to explain these curves, we shall take the case of diverging rays falling upon a spherical surface, as shewn in fig. 63. where DBDF is the spherical surface, C its centre, R the radiant point, RD, RD

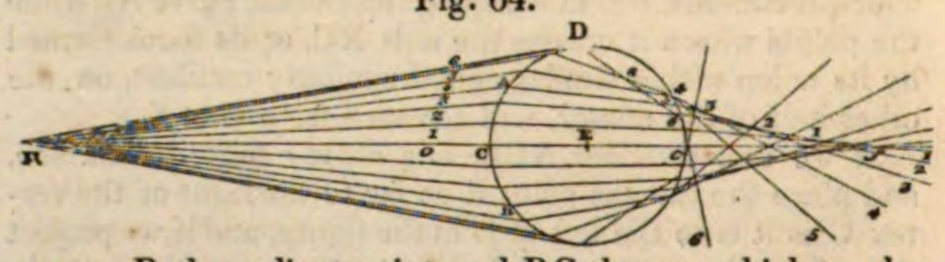
Fig. 63.



two extreme rays touching the sphere, and refracted in the directions D*f*; D*f*, and RB, RB other rays nearer the axis, and refracted in the directions BF, BF. If we join CD, CD, and drawing the semicircles DEC, DEC make the lines DE, CE′ in the same proportion to CD as unity is to the index of refraction, the caustic will begin at EE′ and extending in the directions E, F′, F will approach to the axis RC till it meets it at the principal focus F.

The caustics formed by the two refractions of a sphere, or of a cylinder (in a plane perpendicular to its axis) are shewn in fig. 64, where ACB is the spherical section, E its

Fig. 64.



centre, R the radiant point, and RC the ray which touches the spherical surface. This ray will be refracted by the first surface in the direction 6,6, and by the second surface of the sphere at 6, the other rays R5, R4, &c. will be all refracted in the directions indicated by the numerals 5, 4, &c. and their various intersections will form the caustic 6, 4, 3, 2, 1, *f*, each ray crossing the next ray before it cuts the axis, *f* being the focus or the point where the rays nearest the axis cut it. The luminous figure bounded by the intersection of the successive rays, is composed of the two bright caustic curves. Within these caustics there is also much light arising from the intersections between the caustics and the axis; but as there are no intersections without the caustics they are bounded by absolute darkness.

When parallel rays fall upon the spherical section ACB, the caustic commences at the extremity of a diameter perpendicular to the axis of the section, because the extreme ray suffers refraction at that point, and will intersect the nearest a little within it, and they extend, as in fig. 64, to the principal focus of the sphere for rays near the axis. The real caustic will be the surface formed by the revolution of the curves round the axis E*f*, the section of this curve will be a luminous point at *f*, but at the posterior surface it will be a luminous circle vividly depicted on the sphere. M. Delarive has pointed out a method of determining the index of refraction of solid spheres, or of hollow spheres containing different fluids, by measuring the diameter of this luminous circle, which is smaller in fluids of high than in those of low refractive power. The phenomena of caustics formed by refraction, may be distinctly exhibited by exposing to the rays of the sun, or a strong artificial light, a globe of glass filled with any fluid, or a solid transparent sphere, or the widest part of a round glass decanter. With all these bodies the whole of the luminous figure will be clearly seen. If we use a cylinder full of wa-

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ter, such as a tumbler or a cylindrical bottle, we shall see the caustic curves formed upon a white surface held parallel to the surface of the fluid, the light falling upon the cylindrical surface in the same plane.

PART II. ON THE REFRACTION OF COMPOUND LIGHT, OR THE DOCTRINE OF COLOURS AND THE PRISMATIC SPECTRUM.

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In the preceding pages we have considered white light, whether emanating directly from the sun or from artificial flames, or consisting of the same rays reflected and modified by other bodies, *as a simple element* all the particles of which had the same index of refraction, or suffered the same change of direction when refracted by any transparent body. This, however, is not the nature of light. White light as emitted by the sun or other luminous bodies, is a very *compound element*, all the parts of which possess very different properties, and these properties are of a very remarkable and interesting kind. The power which causes the reflexion of light from polished metallic bodies is not capable of decomposing it, unless when it enters the substance of the metal; but the power which produces refraction is peculiarly influential in separating compound white light into its elements. The same decomposition may be effected by the *interference* of rays of light by *absorption*, and by another principle of analysis, which has been called *dissection*. The two first of these processes of analysis decompose compound light of different degrees of refrangibility; while the two last decompose compound light whose rays have the same refrangibility.

SECT. I.—*On the decomposition of light, and the different refrangibility of its rays.*

Seven colours.

The constituent parts or colours which compose white light, are seven in number, *red, orange, yellow, green, blue, indigo*, and *violet*. These colours have been long observed and studied in the rainbow, and in the refractions produced by lenses and prisms, but till the time of Sir Isaac Newton, no satisfactory explanation had been given of their origin and properties. Descartes had found that colours similar to those of the rainbow were produced by prisms, and he endeavoured to explain them by saying, that the particles of the medium, or matter which transmits light, endeavour to revolve with so great force, that they cannot move in a straight line, whence comes refraction; and that those particles which endeavour to revolve more strongly produce a *red* colour, those that endeavour to move a little more strongly, produce *yellow*, and so on with the other colours. Now this explanation, as Mr. Whewell[1] has justly remarked, though it contains a gratuitous hypothesis respecting the cause of refraction, yet it proves that Descartes considered the different colours as produced by different degrees of refraction. In like manner Grimaldi, as the same author has observed, explains colours by saying, "that the colour is brighter where the light is dense; and the light is denser on the side from which the refraction turns the ray, because the *increments of refraction* are greater than the rays that are more inclined;"[2] that is, that the blue rays are more refracted than the red rays. We cannot agree, however, with Mr. Whewell in the opinion, that this explanation of Grimaldi's might give an explanation of most of the facts, but one much more erroneous than a development of Descartes's views would have been." It appears to us quite manifest, that both Descartes and Grimaldi had a vague sentiment that the different colours were produced by different degrees of refraction, and that Grimaldi's is the most distinctly expressed of the two; but we cannot for a moment agree with the author above quoted, "that Descartes was led very near the same point with Newton." The sentiments expressed by Descartes and Grimaldi, were mere notions of the moment, which authors often throw out without much thought, and which are employed in future times to pervert the history of science. If these two authors really thought that colours were produced by different degrees of refraction, why did they not, as they did other opinions, submit them to the test of an experiment, which required neither thought nor labour, and the means of making which were in their hands. Sir Isaac Newton was well acquainted with the writings of Descartes, and so much with Descartes's *notions* about colours, that the examination of them was the object which he had in view in purchasing his prisms. He never refers to them as anticipatory of his own discoveries, and we must therefore continue to give Sir Isaac the *undivided* merit of the discovery of the unequal refrangibility of light, as well as its experimental establishment.

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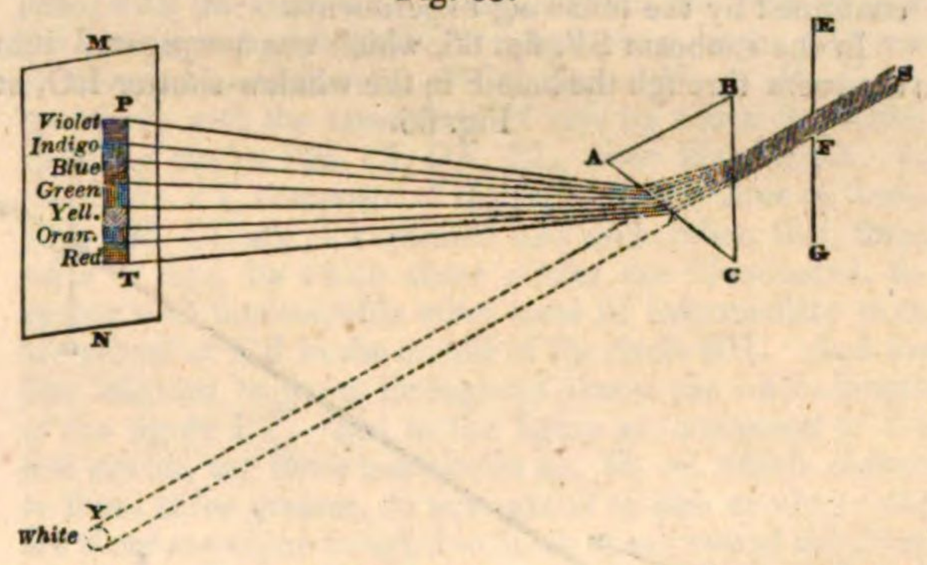
We shall now proceed to give our readers some account of this great discovery, and we shall make no apology in doing this in Sir Isaac Newton's own words, abridging his descriptions where they are redundant, or have become unnecessary. We are induced to do this also, because they exhibit the finest model of experimental research, and should be studied by every person who is desirous of investigating truth with diligence and patience.

1. *The light of the sun consists of rays which differ in colour and refrangibility.*—In a very dark chamber, at a round hole F, fig. 65, about one-third of an inch broad,

Fig. 65.



made in the shutter of a window, I placed a glass prism ABC, whereby the beam of the sun's light, SF, which came in at that hole, might be refracted upwards, toward the opposite wall of the chamber, and there form a coloured image of the sun, represented at PT. The axis of the prism, was, in this and the following experiments, perpendicular to the incident rays. About this axis I turned the prism slowly, and saw the refracted or coloured image of the sun, first to descend, and then to ascend. Between the descent and ascent, when the image seemed stationary, I stopped the prism, and fixed it in that posture, for in that posture the refractions of the light at the two sides of the refracting angles, that is, at the entrance of the rays into the prism, and at their going out of it, are equal to one another.

Then I let the refracted light fall perpendicularly upon a sheet of white paper, MN, placed at the opposite wall of the chamber, and observed the figure and dimensions of the solar image, PT, formed on the paper by that light. This image was oblong, and not oval, but terminated by two rectilinear and parallel sides, and two semicircular ends. On its side it was bounded pretty distinctly; but on its ends very indistinctly, the light there vanishing by degrees. At

[1] *Hist. of Inductive Sciences*, vol. ii. p. 350. [2] Id. Id. p. 352.

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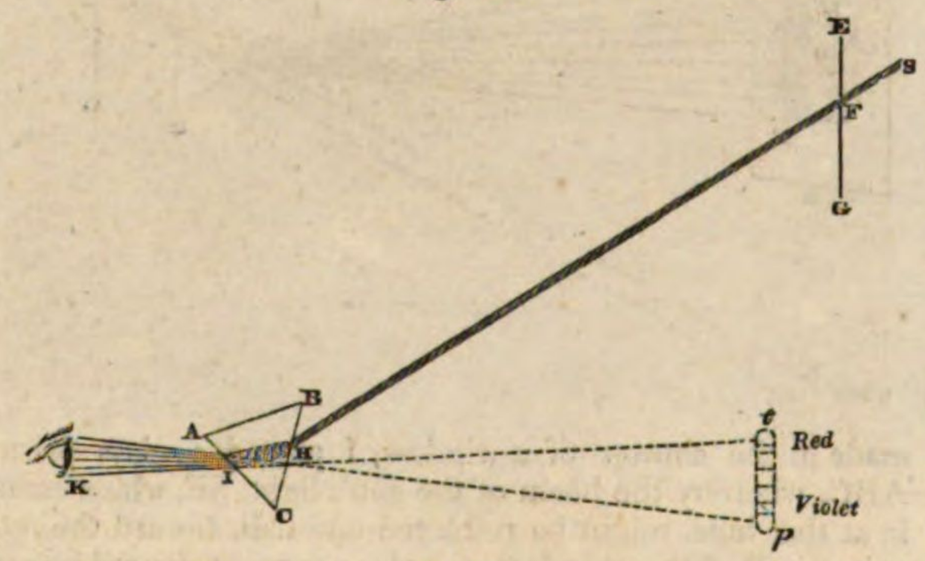
the distance of 18½ feet from the prism the breadth of the image was about 2⅛ inches, but its length was about 10¾ inches, and the length of its rectilinear sides about 8 inches; and ACB, the refracting angle of the prism, by which so great a length was made, was 64 degrees. With a less angle the length of the image was less, the breadth remaining the same. It is also to be observed, that the rays went on in straight lines from the prism to the image, and therefore at their going out of the prism had all that inclination to one another from which the length of the image proceeded. This image PT was coloured, and the more eminent colours lay in this order from the bottom at T to the top at P; *red*, *orange*, *yellow*, *green*, *blue*, *indigo*, and *violet*; together with all their intermediate degrees in a continual succession perpetually varying."

Hence "the light of the sun consists of a mixture of several sorts of coloured rays, some of which at equal incidences are more refracted than others, and therefore are called *more refrangible*. The red at T, being nearest to the place Y, where the rays of the sun would go directly if the prism was taken away, is the least refracted of all the rays; and the *orange*, *yellow*, *green*, *blue*, *indigo*, and *violet*, are continually more and more refracted, as they are more and more diverted from the course of the direct light. For, when the prism is fixed in the posture above mentioned, so that the place of the image shall be the lowest possible, the figure of the image ought to be round, like the spot at Y, if all the rays that tended to it were equally refracted. Therefore, since it is found that this image is not round, but about five times longer than it is broad, it follows, that all the rays are not equally refracted. This conclusion is farther confirmed by the following experiments.

In the sunbeam SF, fig. 66, which was propagated into the room through the hole F in the window-shutter EG, at

Fig. 66.

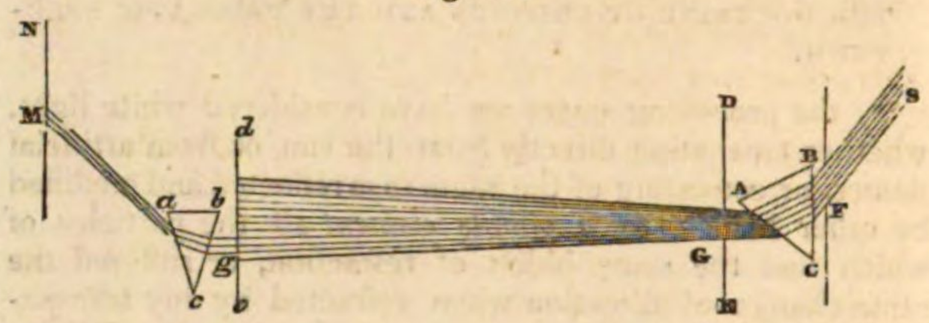


the distance of some feet from the hole, I held the prism ABC in such a posture, that its axis might be perpendicular to that beam: then I looked through the prism upon the hole F, and turning the prism to and fro about its axis to make the image *pt* of the hole ascend and descend, when between its two contrary motions it seemed stationary, I stopped the prism; in this situation of the prism, viewing through it the said hole F, I observed the length of its refracted image *pt* to be many times greater than its breadth; and that the *most refracted* part thereof appeared *violet* at *p*; the *least refracted* appeared *red* at *t*; and the *middle* parts *indigo*, *blue*, *green*, *yellow*, and *orange*, in order. The same thing happened when I removed the prism out of the sun's light, and looked through it upon the hole shining by the light of the clouds beyond it. And yet if the refractions of all the rays were equal according to one certain proportion of the sines of incidence and refraction, as is commonly supposed, the refracted image ought to have appeared round. So then by these two experiments, it appears that in equal incidences there is a considerable inequality of refractions."

Having discovered this fundamental property of light, he contrived the following experiment to prove it by ocular demonstration. Chromatics

"In the middle of two thin boards DE, *de*, fig. 67, I made a round hole in each, at G and *g*, a third part of an inch in

Fig. 67.



diameter; and in the window-shutter a much larger hole being made at F, to let into my darkened chamber a large beam of the sun's light, I placed a prism, ABC, behind the shutter in that beam, to refract it towards the opposite wall; and close behind this prism I fixed one of the boards DE, in such a manner that the middle of the refracted light might pass through the hole made in it at G, and the rest be intercepted by the board. Then, at the distance of about twelve feet from the first board, I fixed the other board *de*, so that the middle of the refracted light, which came through the hole in the first board, and fell upon the opposite wall, might pass through the hole *g* in this other board *de*, and the rest being intercepted by the board, might paint upon it the coloured spectrum of the sun. And close behind this board I fixed another prism *abc*, to refract the light which came through the hole *g*. Then I returned speedily to the first prism ABC, and by turning it slowly to and fro about its axis, I caused the image which fell upon the second board *de* to move up and down upon that board, that all its parts might pass successively through the hole in that board, and fall upon the prism behind it. And in the mean time I noted the places *M*, *N*, on the opposite wall, to which that light after its refraction in the second prism did pass; and by the difference of the places at *M* and *N*, I found that the light, which, being most refracted in the first prism ABC, did go to the blue end of the image, was again more refracted by the second prism *abc*, than the light which went to the red end of that image. For when the lower part of the light which fell upon the second board *de*, was cast through the hole *g*, it went to a lower place M on the wall; and when the higher part of that light was cast through the same hole *g*, it went to a higher place N on the wall; and when any intermediate part of the light was cast through that hole, it went to some place in the wall between M and N. The unchanged position of the holes in the boards made the incidence of the rays upon the second prism to be the same in all cases. And yet in that common incidence some of the rays were more refracted and others less; and those were more refracted in this prism, which by a greater refraction in the first prism were more turned out of their way; and therefore, for their constancy of being more refracted, are deservedly called *more refrangible*."

2. *The light of the sky, or the light of the sun reflected from the first surface of bodies, and also the white flames of all combustibles, whether direct or reflected, differ in colour and refrangibility, like the direct light of the sun.*

The truth stated in this proposition was established by Newton, by examining all those lights with a prism when they were faint, or transmitting them through the prism, as in section 1, when they were sufficiently intense.

3. *The light of the sun consists of rays differing in reflexibility; and those rays that are more refrangible than others are also more reflexible.*

A prism ABC, fig. 68, whose two angles at its base BC were equal to one another and half right ones, and the third

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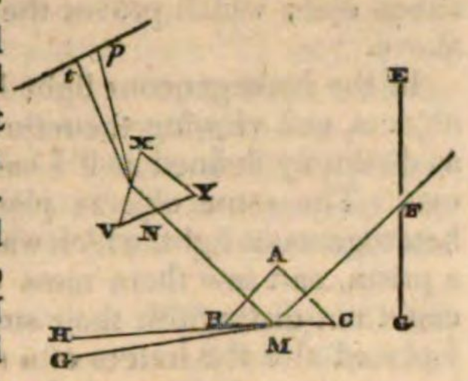
at A a right one, I placed in a beam FM of the sun's light, let into a dark chamber through a hole F, one-third part of an inch broad; and turning the prism slowly about its axis until the light which went through one of its angles ACB, and was refracted by it to G and H, began to be reflected into the line MN by its base BC, at which till then it went out of the glass;

Fig. 68.



I observed that those rays as MH, which had suffered the greatest refraction, were sooner reflected than the rest. To make it evident that the rays which vanished at H were reflected into the beam MN, I made this beam pass through another prism VXY, and being refracted by it to fall afterwards upon a sheet of white paper *pt* placed at some distance behind it, and there by that refraction to paint the usual colours at *pt*. Then causing the first prism to be turned about its axis according to the order of the letters ABC, I observed that when those rays MH, which in this prism had suffered the greatest refraction, and appeared *blue* and *violet*, began to be totally reflected, the *blue* and *violet* light on the paper which was most refracted in the second prism received a sensible increase at *p*, above that of the red and yellow at *t*: and afterwards, when the rest of the light, which was *green*, *yellow*, and *red*, began to be totally reflected, and vanished at G, the light of those colours at *t*, on the paper *pt*, received as great an increase as the *violet* and *blue* had received before. Which puts it past dispute, that those rays became first of all totally reflected at the base BC, which before at equal incidences with the rest upon the base BC had suffered the greatest refraction. I do not here take any notice of any refractions made in the sides AC, AB, of the first prism, because the light enters almost perpendicularly at the first side, and goes out almost perpendicularly at the second; and therefore suffers none, or so little, that the angles of incidence at the base BC are not sensibly altered by it; especially if the angles of the prism at the base BC be each about 40°. For the rays FM begin to be totally reflected when the angle CMF is about 50°, and therefore they will then make a right angle of 90° with AC.

"It appears also from experiments, that the beam of light MN, reflected by the base of the prism, being augmented first by the more refrangible rays, and afterwards by the less refrangible, is composed of rays differently refrangible.

The light whose rays are all alike refrangible, I call *simple*, *homogeneous* and *similar*; and that whose rays are some more refrangible than others, I call *compound*, *heterogeneous*, and *dissimilar*.

The colours of homogeneous lights I call *primary*, *homogeneous*, and *simple*; and those of heterogeneous lights, *heterogeneous* and *compound*. For these are always compounded of *homogeneous* lights.

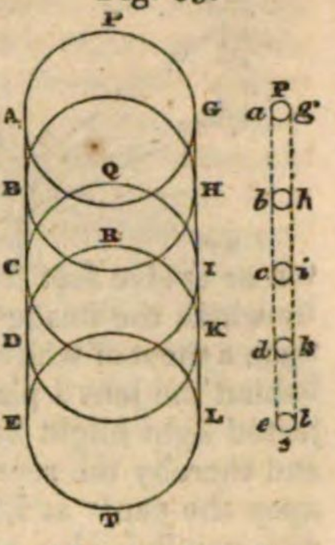
The *homogeneous* light and rays which appear *red*, or rather make objects appear so, I call *red-making*; those which make objects appear *yellow*, *green*, *blue*, and *violet*, I call *yellow-making*, *blue-making*, *violet-making*; and so of the rest. And if at any time I speak of light and rays as coloured or endowed with colours, I would be understood to speak not philosophically. For the rays, to speak properly, are not coloured, and in them there is nothing else than a certain power and disposition to produce a sensation of this or that colour."

4. *To separate from one another the heterogeneous rays of compound light.*

"That the rays which are equally refrangible fall upon a circle answering to the sun's apparent disk, will be proved by experiment by and by.

Let AG, fig. 69, represent the circle which all the most refrangible rays, propagated from the whole disk of the sun, will illuminate and paint upon the opposite wall if they were alone; EL the circle, which all the least refrangible rays would in like manner illuminate if they were alone; BH, CI, DK, the circles which so many intermediate rays would paint upon the wall, if they were singly propagated from the sun in successive order, the rest being intercepted; and conceive that there are other circles without number, which innumerable other intermediate sorts of rays would successively paint upon the wall, if the sun should successively emit every sort apart. And seeing the sun emits all these sorts at once, they must all together illuminate and paint innumerable equal circles; of all which being, according to their degrees of refrangibility, placed in order in a continual series, that oblong spectrum PT is composed, which was described in the first experiment.

Fig. 69.

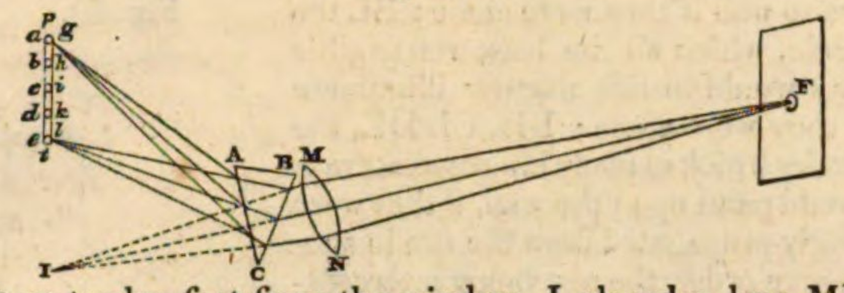


Now, if these circles, whilst their centres keep their distances and positions, could be made less in diameter, their interfering one with another, and consequently the mixture of the heterogeneous rays, would be proportionably diminished. Let the circles AG, BH, CI, &c. remain as before; and let *ag*, *bh*, *ci*, &c. be so many less circles lying in a like continual series, between two parallel right lines *ae*, and *gl*, with the same distance between their centres, and illuminated with the same sorts of rays: that is, the circle *ag* with the same sort by which the corresponding circle AG was illuminated; and the rest of the circles *bh*, *ci*, *dk*, *el*, respectively with the same sorts of rays by which the corresponding circles BH, CI, DK, EL, were illuminated. In the figure PT, composed of the great circles, three of those, AG, BH, CI, are so expanded into each other, that three sorts of rays, by which those circles are illuminated, together with innumerable other sorts of intermediate rays, are mixed at QR in the middle of the circle BH. And the like mixture happens throughout almost the whole length of the figure PT. But in the figure *pt*, composed of the less circles, the three less circles *ag*, *bh*, *ci*, which answer to those three greater, do not extend to one another; nor are there anywhere mingled so much as any two of the three sorts of rays by which those circles are illuminated, and which in the figure PT are all of them intermingled at QR. So then, if we would diminish the mixture of the rays, we are to diminish the diameters of the circles. Now these would be diminished if the sun's diameter, to which they answer, could be made less than it is, or (which comes to the same purpose) if without doors, at great distance from the prism towards the sun, some opaque body were placed with a round hole in the middle of it to intercept all the sun's light, except so much as coming from the middle of his body could pass through that hole to the prism. For so the circles AG, BH, and the rest, would not any longer answer to the whole disk of the sun, but only to that part of it which could be seen from the prism through that hole; that is, to the apparent magnitude of that hole viewed from the prism. But that these circles may answer more distinctly to that hole, a lens is to be placed by the prism to cast the image of the hole (that is, every one of the circles AG, BH, &c.) distinctly upon the paper at PT; after such a manner, as by a lens placed at a window the pictures of objects abroad are cast distinctly upon a paper within the room. If this be done, it will not be necessary to place that hole very far off, no, not beyond the window. And therefore, instead of that hole, I used the hole in the window-shutter as follows.

Chromatics

In the sun's light let into my darkened chamber through a small round hole, fig. 70, in my window-shutter, at about

Fig. 70.



ten or twelve feet from the window, I placed a lens MN, by which the image of the hole F might be distinctly cast upon a sheet of white paper placed at I. Then immediately behind the lens I placed a prism ABC, by which the trajected light might be refracted either upwards or sidewise, and thereby the round image which the lens alone did cast upon the paper at I, might be drawn out into a long one with parallel sides, as represented at *pt*. This oblong image I let fall upon another at about the same distance from the prism as the image at I, moving the paper either towards the prism or from it, until I found the just distance where the rectilinear sides of the images *pt* become most distinct. For in this case the circular images of the hole, which compose that image, after the manner that the circles *ag*, *bh*, *ci*, &c. do the figure *pt*, were terminated most distinctly, and therefore extended into one another the least that they could, and by consequence the mixture of the heterogeneous rays was now the least of all. The circles *ag*, *bh*, *ci*, &c. which compose the image *pt*, are each equal to the circle at I; and therefore, by diminishing the hole F, or by removing the lens farther from it, may be diminished at pleasure, whilst their centres keep the same distances from each other. Thus, by diminishing the breadth of the image *pt*, the circles of heterogeneal rays that compose it may be separated from each other as much as you please. Yet instead of the circular hole F, it is better to substitute an hole shaped like a parallelogram, with its length parallel to the length of the prism. For if this hole be an inch or two long, and but a tenth or twentieth part of an inch broad, or narrower, the light of the image *pt* will be as simple as before, or simpler; and the image being much broader, is therefore fitter to have experiments tried in its light than before."

5. *Homogeneal light is refracted regularly without any dilatation, splitting or shattering of the rays; and the confused vision of objects seen through refracting bodies by heterogeneous light, arises from the different refrangibility of several sorts of rays.*

In the middle of a black paper I made a round hole, about a fifth or a sixth part of an inch in diameter. Upon this part I caused the spectrum of homogeneous light, described in the former proposition, so to fall that some part of the light might pass through the hole in the paper. This transmitted part of the light I refracted with a prism placed behind the paper: and letting the refracted light fall perpendicularly upon a white paper, two or three feet distant from the prism, I found that the spectrum formed on the paper by this light was not oblong, as when it is made in the first experiment, by refracting the sun's compound light, but was, so far as I could judge by my eye, perfectly circular, the length being nowhere greater than the breadth; which shews that this light is refracted regularly without any dilatation of the rays, and is an ocular demonstration of the mathematical proposition mentioned above.

In the homogeneous light I placed a paper circle of a quarter of an inch in diameter; and in the sun's unrefracted, heterogeneous, white light, I placed another paper circle of the same bigness; and going from these papers to the distance of some feet, I viewed both circles through a prism. The circle illuminated by the sun's heterogeneous light appeared very oblong, as in the second experiment, the length being many times greater than the breadth. But the other circle, illuminated with homogeneous light, appeared circular, and distinctly defined, as when it is viewed by the naked eye; which proves the whole proposition mentioned above. Chromatics

In the homogeneous light I placed flies and other minute objects, and viewing them through a prism I saw their parts as distinctly defined as if I had viewed them with the naked eye. The same objects placed in the sun's unrefracted heterogeneous light, which was white, I viewed also through a prism, and saw them most confusedly defined, so that I could not distinguish their smaller parts from one another. I placed also the letters of a small print one while in the homogeneous light, and then in the heterogeneous; and viewing them through a prism, they appeared in the latter case so confused and indistinct that I could not read them; but in the former, they appeared so distinct that I could read readily, and thought I saw them as distinct as when I viewed them with my naked eye: in both cases, I viewed the same object through the same prism, at the same distance from me, and in the same situation. There was no difference but in the lights by which the objects were illuminated, and which in one case was simple, in the other compound; and therefore the distinct vision in the former case, and confused in the latter, could arise from nothing else than from that difference in the lights. Which proves the whole proposition.

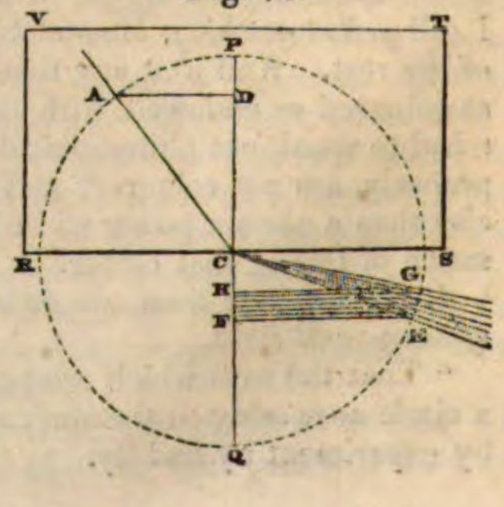
In these three experiments, it is farther very remarkable, that the colour of homogeneous light was never changed by the refraction. And as these colours were not changed by refraction, so neither were they by reflexions. For all white, grey, red, yellow, green, blue, violet bodies, as *paper*, *ashes*, *red lead*, *orpiment*, *indigo*, *bice*, *gold*, *silver*, *copper*, *grass*, *blue flowers*, *violets*, *bubbles of water tinged with various colours*, *peacock feathers*, the tincture of *lignum nephriticum*, and such like, in red homogeneous light appeared totally red, in blue light totally blue, in green light totally green, and so of other colours. In the homogeneous light of any colour they all appeared totally of that same colour; with this only difference, that some of them reflected that light more strongly, others more faintly. I never yet found any body which by reflecting homogeneous light could sensibly change its colour.

From all which it is manifest, that if the sun's light consisted of but one sort of rays, there would be but one colour in the world, nor would it be possible to produce any new colour by reflexions and refractions; and, by consequence, that the variety of colours depends upon the composition of light.

6. *Every homogeneous ray considered apart is refracted, according to one and the same rule; so that its sine of incidence is to its sine of refraction in a given ratio; that is, every differently coloured ray has a different ratio belonging to it.*

Sir Isaac Newton has proved this by experiment; and in other experiments he has determined by what numbers these given ratios are expressed. For instance, if an heterogeneous white ray of the sun emerges out of glass into air; or, which is the same thing, if rays of all colours be supposed to succeed one another in the same line AC, fig. 71. and AD their common sine of incidence in glass be divided into *fifty* equal parts, then EF and GH, the sines of refraction into air, of the least and most refrangible rays, will be 77 and 78 of such parts respectively.

Fig. 71.



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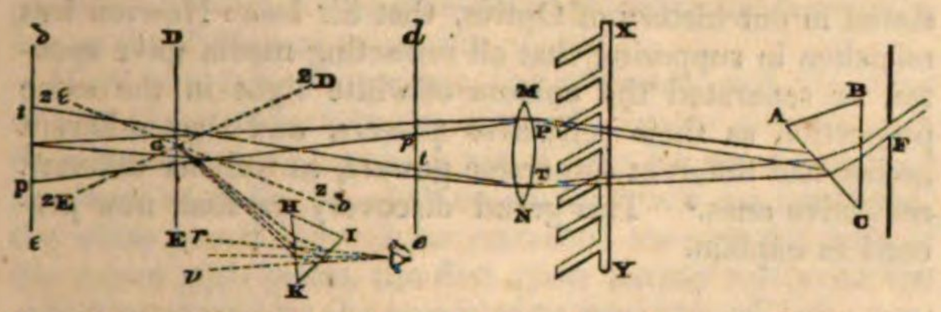
And since every colour has several degrees, the sines of refraction of all the degrees of red will have all intermediate degrees of magnitude from 77 to $77\frac{1}{8}$; of all the degrees of orange from $77\frac{1}{8}$ to $77\frac{1}{7}$; of yellow from $77\frac{1}{7}$ to $77\frac{1}{6}$; of green from $77\frac{1}{6}$ to $77\frac{1}{5}$; of blue from $77\frac{1}{5}$ to $77\frac{2}{5}$; of indigo from $77\frac{2}{5}$ to $77\frac{7}{9}$; and of violet from $77\frac{7}{9}$ to 78.

7. *Whiteness, and all grey colours between white and black, may be compounded of colours; and the whiteness of the sun's light is compounded of all the primary colours, mixed in a due proportion.*

"Let the spectrum or solar image PT, in fig. 72, fall upon the lens MN, above four inches broad, and about six

Fig. 72.



feet distant from the prism ABC, and so figured that it may cause the coloured light which divergeth from the prism to converge and meet again at its focus G, about six or eight feet distant from the lens, and there to fall perpendicularly upon a white paper DE. And if you move this paper to and fro, you will perceive that near the lens, as at *d e*, the whole solar image (suppose at *p t*) will appear upon it intensely coloured after the manner above explained, and that by receding from the lens those colours will perpetually come towards one another, and by mixing more and more, dilute one another continually, until at length the paper come to the focus G, where, by a perfect mixture, they will wholly vanish and be converted into whiteness, the whole light appearing now upon the paper like a little white circle. And afterwards by receding farther from the lens, the rays which before converged will now cross one another in the focus G, and diverge from thence, and thereby make the colours to appear again, but yet in a contrary order; suppose at δ ϵ, where the red *t* is now above which before was below, and the violet *p* is below which before was above.

Let us now stop the paper at the focus G, where the light appears totally white and circular, and let us consider its whiteness. I say, that this is composed of the converging colours. For if any of those colours be intercepted at the lens, the whiteness will cease and degenerate into that colour which arises from the composition of the other colours which are not intercepted. And then if the intercepted colours be let pass and fall upon that compound colour, they mix with it, and by their mixture restore the whiteness. So if the violet, blue, and green be intercepted, the remaining yellow, orange, and red, will compound upon the paper, an orange, and then if the intercepted colours be let pass they will fall upon this compounded orange, and together with it decompound a white. So also if the red and violet be intercepted, the remaining yellow, green, and blue, will compound a green upon the paper, and then the red and violet being let pass, will fall upon this green, and together with it decompound a white. And that in this composition of white the several rays do not suffer any change in their colorific qualities by acting upon one another, but are only mixed, and by a mixture of their colours produce *white*, may farther appear by these arguments.

If the paper be placed beyond the focus G, suppose at $\delta\epsilon$, and then the *red* colour at the lens be alternately intercepted, and let pass again, the *violet* colour on the paper will not suffer any change thereby, as it ought to do if the several sorts of rays acted upon one another in the focus G where they cross. Neither will the *red* upon the paper be changed by any alternate stopping, and letting pass the *violet* which crosseth it. Chromatics

And if the paper be placed at the focus G, and the white round image at G be viewed through the prism at HIK, and by the refraction of that prism be translated to the place *r v*, and there appear tinged with various colours, namely, the *violet* at *v* and *red* at *r*, and others between, and then the *red* colour at the lens be often stopped and let pass by turns, the *red* at *r* will accordingly disappear and return as often, but the *violet* at *v* will not thereby suffer any change. And so by stopping and letting pass alternately the *blue* at the lens, the *blue* at *r* will accordingly disappear and return, without any change made in the *red* at *r*. The *red* therefore depends on one sort of rays, and the *blue* on another sort, which in the focus G, where they are commixed, do not act on one another. And there is the same reason of the other colours.

I considered farther, that when the *most* refrangible rays *Pp*, and the *least* refrangible ones, *Tt*, are by converging inclined to one another, the paper, if held very oblique to those rays in the focus G, might reflect one sort of them more copiously than the other sort, and by that means the reflected light would be tinged in that focus with the colour of the predominant rays, provided those rays severally retained their colours or colorific qualities in the composition of white made by them in that focus. But if they did not retain them in that white, but became all of them severally endued there with a disposition to strike the sense with the perception of white, then they could never lose their whiteness by such reflexions. I inclined therefore the paper to the rays very obliquely, as in the second experiment of this book, that the most refrangible rays might be more copiously reflected than the rest, and the whiteness at length changed successively into blue, indigo, and violet. Then I inclined it the contrary way, that the most refrangible rays might be more copious in the reflected light than the rest, and the whiteness turned successively to yellow, orange, and red.

Lastly, I made an instrument XY, in fashion of a comb, whose teeth were about an inch and an half broad, and the intervals of the teeth about two inches wide. Then by interposing successively the teeth of this instrument near the lens, I intercepted part of the colours by the interposed tooth, whilst the rest of them went on through the interval of the teeth to the paper DE, and there painted a round solar image. But the paper I had first placed so, that the image might appear white as often as the comb was taken away; and then the comb being, as was said, interposed, that whiteness by reason of the intercepted part of the colours at the lens did always change into the colour compounded of those colours which were not intercepted, and that colour was by the motion of the comb perpetually varied, so that in the passing of every tooth over the lens all these colours, red, yellow, green, blue, and purple, did always succeed one another. I caused therefore all the teeth to pass successively over the lens, and when the motion was slow, there appeared a perpetual succession of the colours upon the paper: But if I so much accelerated the motion, that the colours by reason of their quick succession could not be distinguished from one another, the appearance of the single colours ceased. There was no *red*, no *yellow*, no *green*, no *blue*, nor *purple*, to be seen any longer, but from a confusion of them all there arose one uniform *white* colour. Of the light which now by the mixture of all the colours appeared *white*, there was no part *really white*. One part was *red*, another *yellow*, a third *green*, a fourth *blue*, a fifth *purple*, and every part retains its proper colour till it strike the sensorium. If the impressions follow one another slowly, so that they may be severally perceived, there is made a distinct sensation of all the co-

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lours, one after another, in a continual succession. But if the impressions follow one another so quickly that they cannot be severally perceived, there ariseth out of them all one common sensation, which is neither of this colour alone nor of that alone, but hath itself indifferently to them all, and this is a sensation of whiteness."

Such is the account which Newton himself has given of the great discovery of the different refrangibility of light.

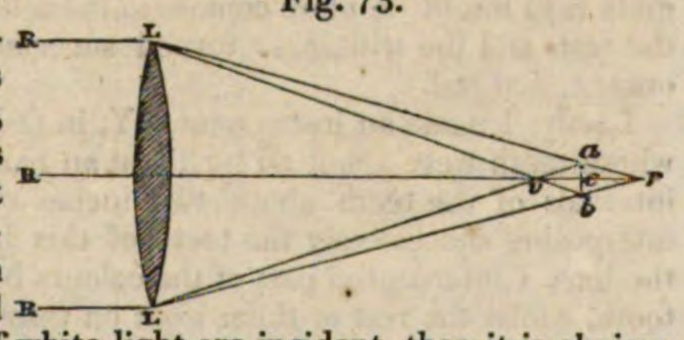
In examining the prismatic spectrum it is difficult to discover the terminations or boundaries of the different colours. They pass into one another by insensible shades, and if any person were to lay down their apparent limits by the nicest observations, he would find, what has been very recently discovered, that these limits vary with the state of the atmosphere, and with the altitude of the sun. Sir Isaac Newton, however, did make the attempt, and the following are the results which he obtained, we believe with crown or plate glass. We have added the results obtained long afterwards by Dr. Wollaston[1] and Mr. Fraunhofer[2] with flint glass, which shews the difficulty of this class of observations.

	Newton in Crown Glass.	Fraunhofer in Flint Glass.	Wollaston in Flint Glass.
Red	45	56	57·6
Orange	27	27	
Yellow	40	27	
Green	60	46	82·8
Blue	60	48	129·6
Indigo	48	47	
Violet	80	109	90
	360	360	360

Imperfection of refracting telescopes.

The influence of these discoveries on the progress of optical science was very remarkable. They led Sir Isaac to discover that the cause of the imperfections of the refracting telescopes was the different refrangibility of the rays of light. If LL, for example, is a lens without spherical aberration, upon which parallel rays R, R, R of white light are incident, then it is obvious that the *violet*, or most refrangible rays will be most refracted in directions L*v*, L*v*, crossing the axis at *v*, and there giving a *violet* focus of light. In like manner the *red*, or the least refrangible rays, will be refracted in directions L*r*, L*r*, crossing the axis at *r*, and there giving a *red* focus of light. In like manner all the other rays will have foci of their own colour between *v* and *r*. If we draw the line *ab*, meeting the intersection of the extreme violet rays after their convergence with the extreme red rays before their convergence, it will cut the axis at a point *c*. The line *vr*, is called the *longitudinal aberration of refrangibility*, or the *longitudinal chromatic aberration*, and *ab* is called the *lateral aberration of refrangibility*, or the diameter of the *circle of diffusion*, all the coloured rays being diffused over the circle, of which *ab* is the diameter. The space *v a r b*, is called the sphere of diffusion; and the section of it shewn in the figure may be regarded as a parallelogram, on account of the smallness of the angles *r*L*v*, *r*L*v*, which are greatly magnified in the figure. Hence it may be easily shewn, that the longitudinal aberration *vr*, is to the lateral aberration *ab*, as the focal distance of the lens is to its radius or half its aperture.

Fig. 73.



In the circle of diffusion *ab*, the light becomes very faint towards *a* and *b*, and very intense in the centre *c*, so that there is formed at *c* a sort of general focus indistinct and coloured. Every part of an object, therefore, will have its image formed in the foci of such a lens similarly indistinct and similarly coloured, and hence we see the reason why refracting telescopes had such great imperfections, that it was necessary to make them of enormous lengths, in order to obtain a sufficient magnifying power.

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From these causes, Sir Isaac Newton despaired of the improvement of refracting telescopes, and set himself at an early period of his life to execute reflecting telescopes. His successors, however, Mr. Hall and Mr. Dollond, studied the object of refraction as produced by prisms made of different substances, and found, as we have already fully stated in our history of Optics, that Sir Isaac Newton was mistaken in supposing that all refracting media gave spectra, or separated the colours of white light in the same proportion as their refractive powers, and that different bodies had different dispersive powers, as well as different refractive ones.[3] This grand discovery we shall now proceed to explain.

Sect. II.—*On the different Dispersive Powers of Bodies.*

Dispersion of light.

The term *dispersion* has been employed to denote the separation of the different rays of white light into that divergent beam which constitutes the prismatic spectrum, the differently coloured rays having been dispersed or scattered by their different refrangibility. Sir Isaac Newton believed that all bodies whatever, whether *water*, or *crown*, or *plate*, or *flint glass*, dispersed light in an equal degree, provided the mean refraction, that is, the refraction of the mean or middle ray of the spectrum (the green ray, viz.), of these bodies was equal, or, in other words, that the dispersion, or the angle formed by the extreme red and the extreme violet ray was in different bodies proportional to the mean refraction.

As Sir Isaac Newton submitted to experiment a number of fluid substances, in the form of prisms, it is perhaps one of the most remarkable oversights in the history of science, that he did not think of comparing the length of the spectra which they formed; and it is equally strange that for more than a century he and all his successors should never have thought of forming the spectrum from any other luminous body less in diameter than the sun, or even from any luminous line of small breadth.[4] The consequence of these oversights was, that the most important discoveries relative to light, and to optical instruments, were reserved for another age.

In our *History of Optics*, and in the article Achromatic Glasses, we have given a detailed history of the successive labours of Hall, Dollond, Euler, and others, by which the achromatic telescope was invented and perfected.

If we perform the experiment shewn in fig. 65, with two prisms, the one of *flint*, and the other of *crown* glass, and measure in each the length of the spectrum PT, or rather the angles which the violet and the red rays PA, TA, make with each other, and the angle which the mean *green* ray forms with the direction of the coloured rays SY, this last angle will be the mean refraction of the prism, and the first the angular dispersion. We shall then find, that while in crown glass the quotient obtained by dividing the greater by the lesser angle, or the part of the mean refraction to which the dispersion is equal, will be seventeen hundredths, ($\frac{17}{100}$), while in flint glass it will be thirty hundredths, ($\frac{30}{100}$), this number varying with the nature of the glass.

This result may be exhibited to the eye, by placing behind a prism of crown glass C, another of flint glass F, of such an angle as not to produce any deviation by refraction, the

[1] See page 414, col. 2.
[2] These results are taken from his coloured figure of the spectrum.
[3] See our Article Achromatic Glasses, vol. i. p. 97.
[4] See page 406, col. 1.

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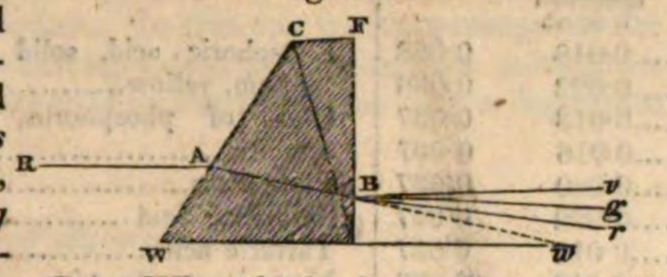
angle of deviation of the green ray produced by the *crown glass* prism C, being compensated by an equal and opposite deviation produced by the *flint glass* prism F; that is, the *green* ray B*g* will emerge parallel to the incident ray RA. When this has been effected it will be seen that there is still a spectrum *rv*, which will colour the edges of any object which is viewed through the prism, and in which will have the same position as if they had been produced by a small flint glass prism placed in the same manner as the flint glass prism F.

Fig. 74.

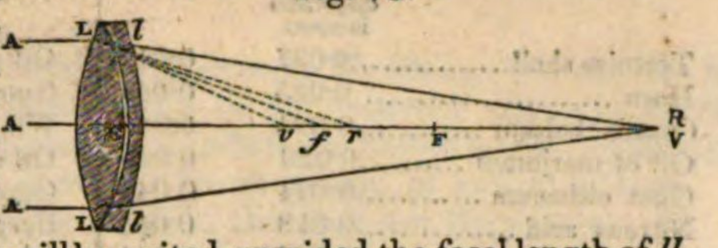


If we now take two prisms, one of *crown*, and the other of *flint* glass, of such angles, that all objects seen through them are colourless, or that a ray of light B*g*, when refracted by them, as in fig. 74, shall be white, it will be found that the white pencil B*w* will be refracted towards the base of the crown glass prism, the flint glass having corrected the colour produced by the crown glass one, but still left a considerable balance of refraction produced by the latter.

Hence it is manifest that the *colours* produced by a convex lens of *crown* glass, as shewn in fig. 73, may be corrected by a concave lens of *flint* glass, while the rays produced by the unbalanced refraction of the convex glass are still converged to a focus. Such a combination of lenses is called an *achromatic object-glass*, and a telescope in which such an object-glass is used is called an *achromatic telescope*.

Nothing is easier than to determine by experiment, when we have obtained good glass for the construction of these lenses, the proper radii to which they should be ground, in order to correct the aberration of colour; but it may be readily shewn, and the reader may easily prove it by the methods already described, that *the aberration of colour produced by a convex lens of crown glass will be corrected by a concave lens of flint glass, provided the focal lengths of the two lenses are proportional to their dispersive power*. Thus, in fig. 75, if LL is a convex lens of crown glass, whose focus for green rays is at *f*, and for violet and red rays at *v* and *r*, and if F is the virtual focus of a concave lens *ll* of flint glass, for the mean green ray, then parallel rays AAA will be refracted to a single focus at RV, where the violet and red rays will be united, provided the focal length of *ll*, viz., EF, is to E*f*, the focal length of LL as 0·068, the dispersive power of *flint* glass, is to 0·033, the dispersive power of *crown* glass. Chromatics

Fig. 75.



The dispersive powers of various glasses, and of some fluids, had been measured with considerable care, in reference to the improvement of the telescope, but no attempt was made to investigate it as a branch of physics, exhibiting new and interesting properties of transparent bodies. Dr. Wollaston set the example of beginning this inquiry, and he determined in a very general manner the dispersive qualities of thirty-three substances, which he arranged in the order of their dispersive powers, without giving any numerical estimate of their value. In this state of the subject, Sir David Brewster, by a new method of measuring dispersive powers, which presented considerable facility of observation, made a very extensive series of experiments on the subject, which, in a physical point of view, presented several curious results. In laying the following table of his observations before our readers, we must warn them that they were made, often with the most imperfect specimens of the minerals and fluid substances, from the difficulty of getting any other, and that they were intended only to indicate the general properties of bodies in dispersing light. The want of fixed points in the spectrum, in reference to which the measures could be taken, rendered it necessary to use the extreme points, which varied with the intensity of the light employed, and with the absorbing action of the bodies themselves, when they happened to be coloured or imperfectly transparent. The discovery of the fixed lines, and their use in measuring dispersive powers, introduced by Fraunhofer, has given a new impetus to this subject, and when it is practicable to obtain good prisms of the substance under examination, no other method will or should be adopted. Dispersive powers of bodies.

Table of the Dispersive Powers of various Solid and Fluid Bodies.

Names of substances.	Part of the whole refraction to which the dispersion is equal.	Dispersive power.
Chromate of lead (greatest refraction), estimated at	0·770	0·400
Chromate of lead (greatest refraction), must exceed	0·570	0·296
Realgar, a different kind, melted	0·394	0·267
Chromate of lead (least refraction)	0·388	0·262
Realgar, melted	0·374	0·255
Oil of cassia	0·089	0·139
Sulphur, after fusion	0·149	0·130
Phosphorus	0·156	0·128
Sulphuret of carbon	0·077	0·115
Balsam of Tolu	0·065	0·103
Balsam of Peru	0·058	0·093
Carbonate of lead (greatest refraction)	+0·091	+0·091
Barbadoes aloes	0·058	0·085
Essential oil of bitter almonds	0·048	0·079
Oil of anise seeds	0·044	0·077
Acetate of lead, melted	0·040	0·069
Balsam of styrax	0·039	0·067
Guiacum	0·041	0·066
Carbonate of lead (least refraction)	0·056	0·066
Oil of cummin	0·033	0·065
Essential oil of tobacco	0·035	0·064
Gum ammoniac	0·037	0·063
Oil of Barbadoes tar	0·032	0·062
Oil of cloves	0·033	0·062
Green coloured glass	0·037	0·061
Sulphate of lead	0·056	0·060
Deep red glass	0·044	0·060
Oil of sassafras	0·832	0·060
Opal-coloured glass	0·038	0·060
Muriate of antimony (refr. pr. 1·598)	0·036	0·059
Rosin	0·032	0·057
Oil of sweet fennel seeds	0·028	0·055
Oil of spearmint	0·026	0 054
Orange-coloured glass	0·042	0·053
Rock salt	0·029	0·053
Flint glass, Boscovich's, highest		0·0527
Caoutchouc	0·028	0·052
Oil of pimento	0·026	0·052
Flint glass	0·032	0·052
Deep purple glass	0·031	0·051
Oil of angelica	0·025	0·051
Oil of thyme	0·024	0·050
Oil of fenugreek	0·024	0·050
Oil of wormwood	0·022	0·049
Oil of pennyroyal	0·024	0·049
Oil of carraway seeds	0·024	0·049
Oil of dill seeds	0·023	0·049
Oil of bergamot	0.023	0·049
Flint glass	0·029	0·048
Chio turpentine	0·028	0·048
Gum thus	0·028	0·048
Oil of lemon	0·023	0·048
Flint glass	0·028	0·048
Oil of juniper	0·022	0·047
Oil of chamomyle	0·021	0·046
Gum juniper	0·025	0·046
Carbonate of strontites, (greatest refraction)	0·032	0·046
Oil of brick	0·021	0·046
Flint glass, Boscovich's, lowest		0·0457
Nitric acid	0·019	0·045
Oil of lavender	0·021	0·045
Balsam of sulphur	0·023	0·045

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Names of Substances.	Part of the whole refraction to which the dispersion is equal.	Dispersive power.
Tortoise shell	0·027	0·045
Horn	0·025	0·045
Canada balsam	0·024	0·045
Oil of marjoram	0·022	0·045
Gum olibanum	0·024	0·045
Nitrous acid	0·018	0·044
Cajeput oil	0·021	0·044
Oil of hyssop	0·022	0·044
Oil of rhodium	0·022	0·044
Pink-coloured glass	0·025	0·044
Oil of savine	0·021	0·044
Oil of poppy	0·020	0·044
Zircon (greatest refr.)	0·045	0·044
Muriatic acid	0·016	0·043
Gum copal	0·024	0·043
Nut oil	0·022	0·043
Burgundy pitch	0·024	0·043
Oil of turpentine	0·020	0·042
Oil of rosemary	0·020	0·042
Feldspar	0·022	0·042
Glue	0·022	0·041
Balsam of Capivi	0·021	0·041
Amber	0·023	0·041
Oil of nutmeg	0·021	0·041
Stilbite	0·021	0·041
Oil of peppermint	0·019	0·040
Spinelle ruby	0·031	0·040
Calcareous spar (greatest refraction)	0·027	0.040
Oil of rapeseed	0·019	0·040
Bottle glass	0.023	0·040
Tartrate of potash and soda	0·020	0·039
Carbonate of potash (greatest refraction)	0·013	0·039
Gum elemi	0·021	0·039
Sulphate of iron	0·019	0·039
Diamond	0·056	0·038
Oil of olives	0·018	0·038
Gum mastich	0·022	0·038
White of an egg	0·013	0·037
Oil of rhue	0·016	0·037
Gum myrrh	0·020	0·037
Beryl	0·022	0·037
Obsidian	0·018	0·037
Ether	0·012	0·037
Selenite	0·020	0·037
Alum	0·017	0·036
Castor oil	0·018	0·036
Sulphate of copper	0·019	0 036
Crown glass, very green	0·020	0·036
Gum Arabic	0·018	0·036
Sugar, after being melted and cooled	0·020	0 036
Jelly fish, body of, (*medusa æquorea*)	0·013	0·035
Water	0·012	0·035
Aqueous humour of a haddock's eye	0·012	0·035
Vitreous humour of ditto	0 012	0·035
Citric acid	0·019	0·035
Rubellite	0·027	0·035
Leucite	0·018	0·035
Epidote	0·024	0·035
Common glass, Boscovich's, highest		0·0346
Glass of borax	0·018	0·034
Garnet	0·027	0·033
Pyrope	0·026	0·033
Chrysolite	0·022	0·033
Crown glass	0·018	0·033
Common glass, Boscovich's, lowest		0·033
Oil of ambergris	0·012	0·032
Oil of wine	0·012	0·032
Phosphoric acid, solid prism, yellow	0·017	0·032
Glass of phosphorus, white	0·017	0·032
Plate glass	0·017	0·032
Sulphuric acid	0·014	0·031
Tartaric acid	0·016	0·030
Nitre, least refraction	0·009	0·0304
Borax	0·014	0·030
Axinite	0·022	0·030
Alcohol	0·011	0·029
Sulphate of barytes	0·011	0·029
Tourmaline	0·019	0·028
Phosphoric acid, fluid	0·012	0·0283
Carbonate of barytes, least refraction[1]	0·015	0·0285
Malic acid	0·011	0·0282
Carbonate of strontites, least refraction	0·015	0.027
Crown glass, Leith, Robison		0·033
Rock crystal	0·014	0·026
Emerald	0·015	0·026
Borax glass, 1 bor. 2 silex	0·014	0·026
Calcareous spar, least refraction	0·016	0·026
Blue sapphire	0·021	0·026
Bluish topaz from Cairngorm	0·016	0·025
Chrysoberyl	0·019	0·025
Blue topaz, from Aberdeenshire	0·016	0·024
Sulphate of strontites	0·015	0·024
Carbonate of potash,[2] least refraction	0·0088	0·0233
Prussic acid	0·008	0·0227
Fluor spar	0·010	0·022
Cryolite	0·007	0·022

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The following measures of the dispersive powers of several varieties of glass were taken by Sir John Herschel, by a method which gave him nearly the extreme rays of the spectrum, namely, by viewing the spectrum through a dark blue glass, which stops the *green*, *yellow*, and most refrangible *red* rays, and therefore allows the extreme rays of the spectrum to be seen,—rays which the eye does not recognise in any of the ordinary lights which are used in optical instruments. If we condense the sun's light, as we have done, in order to render visible rays at the extremities of the spectrum, that have not been recognised, we should obtain dispersive powers still higher than those given by Sir John Herschel. By determining, however, the extremities of the spectrum seen by the ordinary light of the sky, it would be easy to accommodate all measures of dispersive power taken in such a light to those taken in the light used by Sir John Herschel, or in the more condensed and consequently elongated spectrum to which we have referred. In order that the measures in the following tables may be correct, it is necessary that they should all have been taken when the sun had the same altitude, because it is quite certain that the violet part of the spectrum diminishes in length very rapidly as the sun approaches the horizon, and some change also takes place at the red extremity.

Dispersive Powers of different kinds of Glass.

	Part of the whole refraction to which the dispersion is equal.	Dispersive power.
Flint glass,	0·03849	0·06404
Ditto,	0·03705	0·06409
Flint glass,	0·03734	0·06386
Ditto, heavy,	0·03951	0·06555
Ditto,	0·03747	0·06409
Crown glass,	0·02139	0·04063
Ditto, a different kind,	0·02494	0·04704
Plate glass,	0·02616	0·05090

Sir John Herschel justly remarks, that it ought not to excite surprise that the dispersions deduced by this method should considerably exceed all former estimates.[3]

Explanation of the Tables.

In the preceding table of dispersive powers we have given two columns of numerical results, the first column containing the part of the whole refraction, or angle of deviation to which the angle of dispersion is equal, and the other the dispersive power itself. The first column is obviously not a measure of the dispersive power, because if the dispersion in that column is $\frac{1}{20}$th part of a low refraction in one body, and the 20th part of a high refraction in another body of great refractive power, the dispersive power of the latter must be smaller than that of the former, in the inverse ratio of the index of refraction of the two bodies minus unity. Hence the numbers in the second column, the dispersive powers, are obtained by dividing the first column by the index of refraction minus one.

Absolute dispersive power.

If we wish to have the intrinsic or *absolute* dispersive powers of bodies, in reference to the action of their ultimate molecules on the theory of emission, and on the supposition, as Sir John Herschel has remarked, in reference to absolute

[1] The dispersive power of the other image is considerably greater than this. See *Edin. Trans.* vol. vii. p. 289.
[2] The least refractive index of this salt, which is not inserted in our table, p. 384, is 1·379.
[3] *Edin. Trans.* vol. ix. p. 458.

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refractive powers, *of the ultimate atoms of all bodies being equally heavy*, we must divide the numbers in the second column of the preceding table by the specific gravities or densities of the bodies. In this way we have computed the results in the following table, containing the substances principally that exercise an extreme action in the dispersion of light.

Table of Absolute Dispersive Powers.

	Specific gravities used.	Absolute dispersive power.
Sulphate of barytes,	4·48	0·00602
——— strontites,	3·95	0·00607
Carbonate of barytes,	3·70	0·0063
Sapphire,	3·50	0·0066
Chryso-beryl,	3·93	0·00675
Topaz,	3·50	0·00685
Fluor spar,	3·17	0·0069
Cryolite,	2·95	0·0074
Diamond,	3·50	0·0109
Plate glass,	2·76	0·0112
Rock salt,	2·143	0·0250
Water,	1·00	0·035
Amber,	1·04	0·0400
Oil of olives,	0·913	0·0415
Oil of turpentine,	0·87	0·0483
Sulphur, fused,	2·00	0·065
Realgar,	3·50	0·0728
Phosphorus,	1·75	0·0731
Oil of anise seeds,	0·987	0·078
Bi-sulphuret of carbon,	1·27	0·081
Oil of cassia,	1.044	0·131

These results present us with several views of considerable interest. The salts of barytes have, in reference to their density, the least dispersive power of all bodies, and the next in order are the gems, including even diamond, which occupies so different a place in our table of absolute refractive powers. The inflammable bodies, with the exception of diamond, stand at the head of the table, *oil of cassia* having by far the greater absolute dispersive power of any body yet examined. That this is owing to the hydrogen which it contains is very probable, and has almost been proved by an experiment by Sir John Herschel, who deprived a portion of this oil of most of its hydrogen by making a stream of chlorine pass through it till it refused to act any farther. By this means he converted the oil into a viscous mass, the dispersive power of which was diminished one-half, while its refractive power had hardly suffered any change. This result leads us to conclude that *hydrogen* has the greatest intrinsic dispersive power of all bodies. *Fluorine* seems to be the element which has nearly the lowest refractive power.

Double dispersive power.

One of the most interesting results exhibited in the general Table of dispersive powers, relates to the dispersive powers of doubly refracting substances. Dr. Wollaston had measured the dispersive power of the ordinary ray in calcareous spar, so far at least as to ascertain that it stood above water, and plate and crown-glass. Sir David Brewster had been led to measure the dispersion of the extraordinary ray, and found it to be much lower than that of water. He was hence induced to examine the dispersive powers of other doubly refracting crystals, and was thus led to the result which we have stated.[1] Similar results have been more recently obtained by M. Rudberg and Mr. Cooper, without knowing that the subject had been previously investigated.

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SECT. III.—*On the Irrationality of the Coloured Spaces in the Spectrum, and the existence of a secondary Spectrum.*

Secondary spectrum. Clairaut.

We are indebted, we believe, to M. Clairaut for the discovery of the irrationality of the coloured spaces in the spectrum. He found that when the flint-glass of an achromatic object glass had its aberration of colour as completely corrected as possible, that is, when the extreme red and violet rays were accurately united in the same focus, still there remained a portion of incorrected colour, which was of a purple or claret colour on one side of the focus, and of a green colour on the other. If prisms had been used in place of lenses, and the sun's light transmitted through them in the usual manner, there would have been a small recidual spectrum, or *secondary spectrum* as it has been called, consisting of purple and green light. The Abbé Boscovich afterwards observed the same fact, but considered it so extraordinary that he suspected some latent cause of error, and submitted his experiments to the most rigid scrutiny. He at last admitted the irrationality of the coloured spaces in the spectrum as a demonstrated truth, and has shewn how three of the colours of the spectrum may be corrected or united in the same focus in achromatic telescopes. The late Professor Robison obtained similar results, and gave the name of *outstanding* colours to those which were not united, and form the secondary spectrum.

Boscovich.

Robison.

Blair.

This subject was more fully investigated by Dr. Blair, in his interesting paper on the unequal refrangibility of light,[2] and he has shewn that the proportions of the coloured spaces vary with the substance of the opposing prisms, so that a complete correction of colour cannot possibly be effected by two media of different dispersive powers. Hence Dr. Blair was led to examine the nature of the dispersive action of different media, and by the most ingenious devices succeeded in producing fluid object-glasses in which the *aberration of colour was completely corrected.* The telescopes which he made on this principle were so extraordinary, that Professor Robison assures us that one of them, FIFTEEN inches in focul length, *equalled in all respects, if it did not surpass, the best of Dollond's* FORTY-TWO inches long.

Wollaston.

Under these circumstances, the scientific world was surprised at the following statement published by Dr. Wollaston in the *Phil. Trans.* for 1803. "Since the proportions of these colours *have been* supposed by Dr. Blair to vary according to the medium by which they are produced, I have compared with this appearance, the coloured images caused by prismatic vessels containing substances supposed by him to differ most in this respect, such as strong but colourless nitric acid, rectified oil of turpentine, very pale oil of sassafras, Canada balsam, also nearly colourless. With each of these, I have found the same arrangement of these four colours, and in similar positions of the prisms, as nearly as I could judge, the same proportions of them." Dr. Blair was surprised that Dr. Wollaston should have used such a coarse method of determining a point that required delicate observations, especially with the substances above mentioned; and he remarked to the writer of this article, that if Dr. Wollaston would only make use of lenses, he would see his mistake after a single observation.

There is no doubt, however, that the secondary spectrum can be made very visible by prisms, and if we use a prism of oil of cassia to correct the colour produced by another of sulphuric acid, we shall have a striking ocular proof of the existence of a large secondary spectrum.

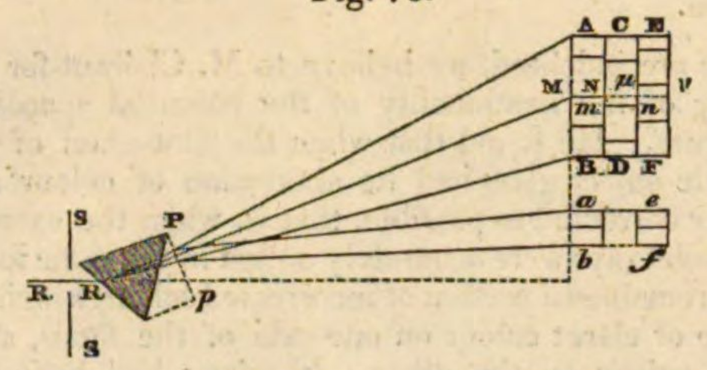
The phenomena of a secondary spectrum will be understood from fig. 76, where RR is a ray passing through an aperture in the window-shutter SS, and refracted by a prism P in the direction PM, so as to form the spectrum AB on the

[1] See *Phil. Trans.* 1813, p. 107, where this result was first published.

[2] *Edin. Trans.* vol. iii. p. 3.

Chromatics wall, PA being the extreme violet ray, PM the mean ray, and PB the extreme red. The spectrum will consist of four

Fig. 76.



palpable colours, *red, green, blue, and violet*, and if the prism is one of *crown-glass*, the mean ray PMN which bisects the spectrum will be at the boundary of the blue and green spaces. If we were to take a prism of flint-glass with a much less refracting angle, and form a spectrum CD of the same length as AB, and at the same distance from the prism, the line *mn* which marks the boundary of the blue and green spaces will no longer be the mean ray of the spectrum, but will be decidedly nearer the *red* extremity D. The least refrangible half of the spectrum has therefore been more contracted, and the most refrangible half more expanded than in the crown-glass spectrum. If we now take a prism of sulphate of barytes or fluor spar, capable of forming a third spectrum EF of the same length as the other two, the boundary of the blue and green spaces will now be at $\mu\nu$ nearer the violet than the red extremity of the spectrum, and the least refrangible half of this spectrum will be more *expanded*, and the most refrangible half more *contracted*, than in the crown-glass spectrum.

"If a spectrum," says Sir David Brewster, [1] "formed by flint-glass, had its coloured spaces exactly of the same dimensions with those of an equal spectrum formed by crown-glass, any object such as a window-bar lying parallel to the common section of the refracting planes of the two prisms should appear perfectly colourless when seen through the combined prisms. But if the coloured spaces in the two spectra are not proportional, as shewn in fig. 76, but are *irrational*, then the window-bar cannot be wholly free from colour, for though the extreme red and violet rays of both the spectra are united, yet the intermediate colours are not rendered coincident. In the spectrum AB, formed by the crown-glass, the first green ray MN, which is here the mean ray, is obviously more refracted than the first green ray *mn*, in the spectrum CD formed by the flint-glass, and therefore the flint-glass will not be able to refract the green ray, so as to unite it with the red and violet. Hence the green ray will, as it were, be left behind, while the red and violet rays are rendered coincident. Thus, in fig. 76, if a prism *p* of flint glass is placed behind a crown-glass prism P, so as exactly to correct its dispersion, the spectrum AB will be reduced to a secondary spectrum *ab*, the upper half of which is *green*, which is left behind, and the lower half is of a *claret* colour, formed by the union of the red and violet rays. If the bar of a window had been examined through the combined prisms P, *p*, the upper side of it would have been tinged with green, and the lower side of it with a claret-coloured fringe.

By comparing, in a similar manner, the spectrum EF, formed by fluor spar, with the spectrum AB, formed by crown glass, it will be found, that the fluor spar having a greater action than the crown glass upon the green ray, will carry it beyond the place of the united red and violet, and will form a secondary spectrum *ef*, the lower half of which is *green*, and the upper half of a *claret* colour, arising from the union of the red and violet light. If the bar of a window were viewed through the combined prisms of crown-glass and rock crystal, it would be tinged with green on its lower side, and with a claret-coloured fringe on its upper side. Chromatics

When a horizontal window-bar, therefore, is seen through any two prisms which correct each other's dispersion, without uniting all the colours, the green fringe will always be on the same side of the bar with the vertex of the prism which has the least action upon the green light, or which *contracts* the red and green rays, and *expands* the blue and violet ones; that is, if the vertex of the flint glass prism is pointing downwards, the uncorrected green fringe will be on the lower side of the bar. By observing, therefore, the position of the green fringe, we can immediately ascertain which of the two prisms has the greatest action upon the green light.

These theoretical deductions from the assumed inequality of the coloured spaces are completely established by observation.

The following Table contains the result of a numerous series of observations made by Sir David Brewster on the secondary spectra of different bodies, the substances being arranged inversely according to their action upon green light. The bodies at the top of the Table form spectra, in which the red and green spaces are most contracted, and the blue and violet ones most expanded. The relative position of some of the substances, particularly the essential oils, is quite empirical; but by a reference to the original experiments, it will be seen whether or not the relative action of any two bodies has been determined.

Table of Transparent Bodies, arranged inversely according to their Action upon Green Light.

1	Oil of Cassia.		Balsam of capivi.
	Sulphur.		Oil of fenugreek.
	Sulphuret of Carbon.		Oil of rosemary.
	Balsam of Tolu.		Oil of rhodium.
5	Carbonate of lead.	50	Flint Glass.
	Essential oil of bitter almonds.		Zircon.
	Oil of anise seeds.		Oil of olives.
	Oil of cummin.		Oil of rape seed.
	Oil of sassafras.		Oil of spermaceti.
10	Oil of amber.	55	Oil of Juniper.
	Acetate of lead melted.		Oil of ambergris.
	Opal-coloured glass.		Calcareous spar.
	Orange-coloured glass.		Rock-salt.
	Red-coloured glass.		Gum juniper.
15	Oil of sweet fennel seeds.	60	Tartrate of potash and soda.
	Oil of cloves.		Oil of almonds.
	Muriate of antimony.		Crown Glass.
	Oil of lavender.		Gum-Arabic.
	Canada balsam.		Alcohol.
20	Oil of Turpentine.	65	Ether.
	Oil of sage.		Borax, glass of.
	Oil of pennyroyal.		Borax.
	Oil of poppy.		Tourmaline.
	Oil of hyssop.		Leucite.
25	Oil of spearmint.	70	Selenite.
	Amber.		Beryl.
	Oil of lemon.		Topaz blue.
	Oil of caraway-seeds		Fluor spar.
	Oil of nutmegs.		Citric Acid.
30	Oil of thyme.	75	Malic Acid.
	Oil of peppermint.		Ascetic acid.
	Oil of bergamot.		Nitrous acid.
	Oil of marjoram.		Muriatic acid.
	Oil of wormwood.		Prussic acid.
35	Oil of dill seeds.	80	Nitric acid.
	Oil of chamomyle.		Rock crystal.
	Castor-oil.		White of an egg.
	Gum copal.		Ice.
	Rosin.		Water.
40	Diamond.	85	Super-sulphuretted hydrogen.
	Nitrate of potash.		Phosphorous acid.
	Oil of beech-nut.		Sulphurous acid.
	Oil of rue.		Phosphoric acid.
	Oil of Savine.	89	Sulphuric Acid.
45	Nut-oil.		

[1] *Treatise on New Philosophical Instruments*, 1813, p. 316.

Chromatics

Dr. Blair's aplanatic telescopes.

Finding it impossible to obtain any highly dispersing medium which should refract the rays of the spectrum in the same manner as crown glass, Dr. Blair thought of employing this very imperfection in obtaining a perfect correction of colour. As the green rays removed the outstanding ones, or were not united in the same focus with the red and violet, he considered that if an achromatic *concave* lens should refract the outstanding green more strongly than the united red and violet, while an achromatic *convex* lens should also refract the outstanding green more strongly than the united red and violet, then two such achromatic lenses combined might unite the outstanding green with the red and violet, and thus effect a perfect union of all the colours. Hence he took the combination shewn in fig. 77, for a concave lens, composed of a concave lens *ab*, of crown glass, and a convex lens *cd* of a fluid which had its dispersive power of such a character as to unite the *red* and *violet* rays as stated in the figures, and leave the green outstanding and *most refracted*. He then made an achromatic *convex* lens, fig. 78, composed of a convex lens *hg* of an essential oil, the same as that in *cbd*, which disperses the rays in a lesser degree, and of a concave lens *fehg* of an essential oil which disperses the rays in a much greater degree. This compound lens has its convexity such as to unite at a convenient distance, rays which diverge from the violet focus of the compound concave lens shewn in fig. 77, and therefore its focal length must be much shorter than the other, like the flint lens in a common achromatic. But though the focal lengths of the two compound lenses are thus different, yet, the distance or deviation of the outstanding green, from the united red and violet, is equal in both.

Fig. 77.

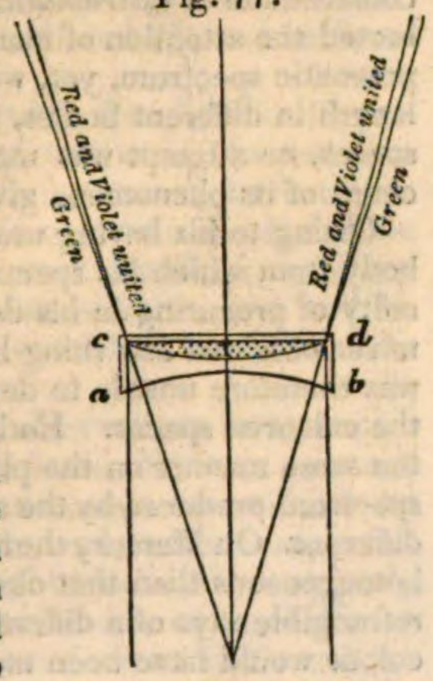


Fig. 78.

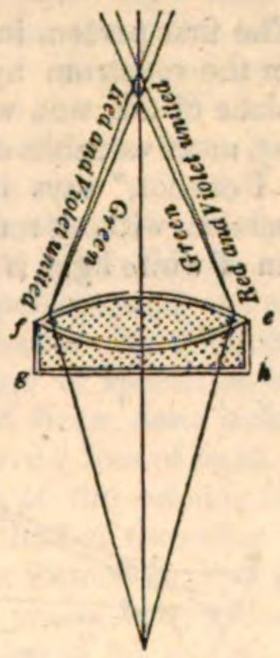
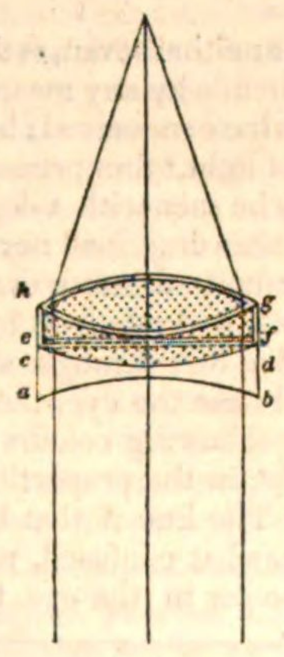


Fig. 79.

When these two compound lenses are placed in contact, as shewn in fig. 79, it is manifest that the equal and opposite deviations of the green ray will balance each other, and that this ray will therefore be united with the red and violet, and thus form a pencil exempt from secondary colours. The plates of glass shewn by dotted lines at *ef*, *cd*, though necessary when the two compound lenses are separate, as in fig. 77, 79, are of course removed, since the two fluids which they separate, as fig. 78, are the same. Hence the compound object-glass, consists of a concave lens of crown glass *ab*, of a meniscus *ef*, of a fluid, and a convex glass of another fluid, enclosed in two glasses like watch-glasses. Dr. Blair found it best in practice to make all the glasses concave meniscuses in place of having all the concavity in one lens *ab*.



Chromatics

In continuing his experiments, Dr. Blair happened to try the muriatic acid mixed with a metallic solution; he found it best to make his compound convex lens, as shewn in fig. 78, of crown glass, and that fluid which enabled him to correct the colour of the compound concave in fig. 77, and likewise to correct the aberration of figure by a concave which lengthens only by one-third the focal distance of the convex.

When he was trying a compound concave formed only of crown glass and muriatic acid, he observed that this fluid produced an inverted secondary spectrum, and gave a primary spectrum, in which the green rays were among the most refrangible, and hence he was conducted to the idea of forming a compound lens consisting merely of a single concave lens of muriatic acid placed between a plano-convex and a meniscus of crown glass. In this lens, which he actually constructed and used, he observes *that the rays of different colours were bent from their rectilineal course with the same equality and regularity as in reflexion.*[1]

Fig. 80.

In such telescopes, Dr. Blair found that when the focal length of the object-glass was *nine inches*, the aperture might be increased as far as *three* inches; and in order to distinguish such instruments where the aberration is removed from *achromatic* ones in which it is only partially removed, he proposes the use of the term *aplanatic*.[2]

SECT. IV.—*On the tertiary spectrum, and the method of correcting the aberration of colour by prisms and lenses of the same kind of glass.*

Tertiary spectrum.

The existence of the *tertiary* spectrum was discovered experimentally by Sir David Brewster, who deduced it also from the constant ratio of the sines. It is produced when the dispersion of a prism of any substance is corrected by another prism of the same substance with a different refracting angle. An irrationality takes place in the coloured spaces, which prevents the correction of colour from being complete. The residuary spectrum was therefore called the *tertiary* spectrum merely to distinguish it from the *secondary* one, which is produced by the specific quality in the refracting media, which act in opposition to each other.

In examining the phenomena of this new spectrum; Sir David Brewster was led to a very paradoxical method of exhibiting it.

Fig. 81.

Having formed a prism of oil of cassia, with a large refracting angle, and viewing through it the broadest horizontal bar of a window, so that the edges of the bar were free of all colours, he inclined the prism so as to make the bar exhibit at its edges the prismatic colours, as shewn in fig. 81, where the edges *b*M and *e*N had spectra *ba*M, *ef*N, consisting of the usual *red* and *yellow* rays, while the edges *e*M, *b*N had spectra *ed*M, *bc*N composed of the usual blue and violet rays. These spectra increased from *b* and *e* towards M and N, and at the nodes *b*, *e*, where the spectra would have vanished, had each face of the prism received the rays symmetrically, the *tertiary spectrum* was clearly displayed in the form of a *green* and *purple* fringe.

In order to produce refraction without colour by two prisms of the same kind of glass, they may be combined, as in fig. 82, where a ray of light R incident on the first prism AB is refracted to the axis MF at F. The prism AB has a smaller refracting angle than CD, and is placed in an oblique position, so that its dispersion is increased in a greater ratio

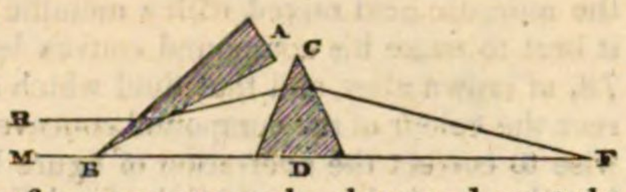
[1] *Edin. Trans.* vol. iii, p. 53.

[2] *Id. Id.*

Chromatics

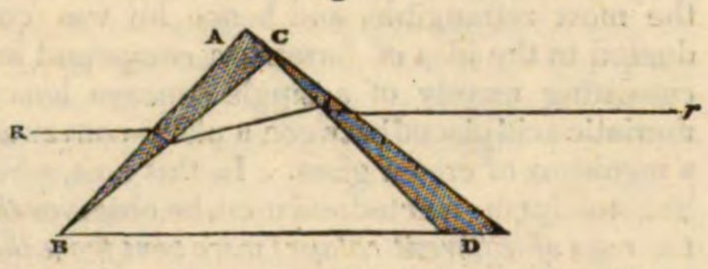
than its refraction, for the purpose of correcting the dispersion of CD without balancing its refraction; the prism CD having a position in which its refraction and dispersion are a minimum. The ray R will therefore converge colourless, and meet the axis at F.

Fig. 82.



If the prisms have the same refracting angle, and are placed in the position shewn in fig. 83, the ray R will emerge colourless in the direction *r*. This combination of prisms, as well as that in fig. 82, has the property of expanding all objects viewed through them, in a vertical plane passing through their sections BACD, that is, of *magnifying them in one plane*. Hence, if we place another similar pair of prisms horizontally, this pair also will magnify objects in a horizontal plane, and by combining these two pair of prisms, we obtain an instrument which will expand or magnify objects in all directions.

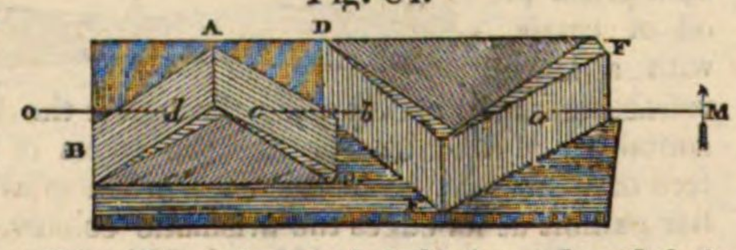
Fig. 83.



This instrument was first constructed by Sir David Brewster in 1812, under the name of a *teinoscope*, for altering the proportions of objects in plans and drawings, by expanding them differently in rectangular directions;[1] and there is reason to think that Dr. Blair was early acquainted with this method of magnifying objects by prisms. Mr. Archibald Blair a few years ago put into Sir David Brewster's hands an instrument of this kind, composed of four prisms which had been executed by his father, but the date of its construction he had no means of discovering. There cannot, therefore, be the shadow of a doubt that both the principles and the invention of an instrument for magnifying objects by means of prisms, were known and published in Scotland long before the celebrated M. Amici of Modena brought forward a contrivance of the same kind. That M. Amici's invention was an independent one will not be questioned.

As we conceive that a telescope of this kind may have many useful applications, we have given in the annexed figure a sketch of the instrument as actually fitted up for use. It consists of two prisms, AB, AC of the same kind of glass, and having a small refracting angle.

Fig. 84.



Their common line of junction at A is horizontal, and their planes of refraction vertical. Other two similar prisms DE, EF, are placed transversely, their common line of junction at E being vertical, and their planes of refraction horizontal. An object M, therefore, seen through the prisms in the direction OM, by an eye placed at O, will be magnified three, four, or five times, or more according to the inclination and angles of the prisms. It is expanded or stretched out in a horizontal plane by the two first prisms ED, EF, and then expanded and stretched out in a vertical plane by the other two prisms, AB, CD.

If we use homogeneous light, we may construct the instrument with only two prisms, as there is no necessity for correcting the colour with a second prism. For solar observations, the two prisms will constitute a telescope, a darkening glass being used as in other instruments. It will be thus equally useful for viewing the lines in the spectrum, where homogeneous light is necessarily used; and by placing two, three, or four instruments in the same tube, we may obtain any magnifying power we desire. The writer of this article is at present occupied with the construction of one of these instruments with rock salt prisms. The length of the instrument which we have drawn is only *two inches and three quarters*.

Prismatic Spectrum.

Sect. V.—*On the Optical Phenomena of the Spectrum.*

Phenomena of the spectrum.

Although the discovery of the principle, and the actual construction of *achromatic* and *aplanatic* telescopes had directed the attention of many observers to the nature of the prismatic spectrum, yet, with the exception of its varying length in different bodies, and the continuity of its coloured spaces, no attempt was made to question the general account of its phenomena given by Sir Isaac Newton.

Owing to his having used the diameter of the sun as the body from which his spectrum was formed, and to the difficulty of procuring in his day good prisms of glass, Sir Isaac never obtained any thing like pure homogeneous light, and was therefore unable to determine the exact boundaries of the coloured spaces. Had the spectrum been observed in the same manner on the planet Mercury and on Saturn, the spectrum produced by the same prism would have been very different. On Mercury the rays would have been less pure and homogeneous than that observed on our earth, and the mean refrangible rays of a different colour; while on Saturn the colour would have been more pure and homogeneous.

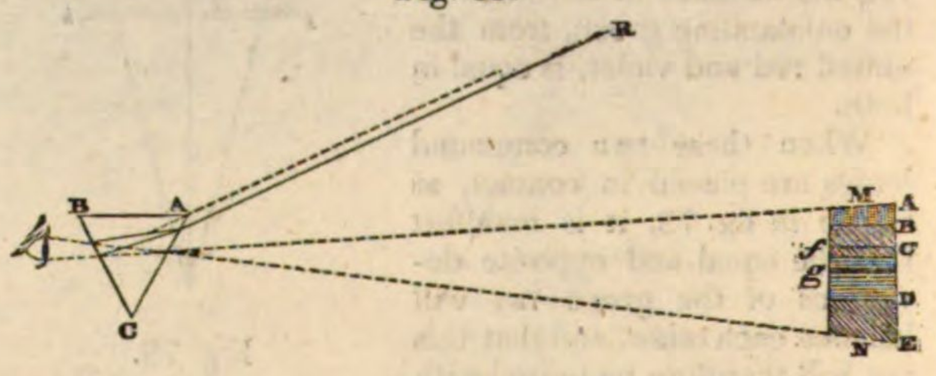
1. *Discoveries of Dr. Wollaston.*

Discoveries of Dr. Wollaston.

The first person, in so far as we know, who proposed to form the spectrum by using *a very narrow pencil of light* in place of the sun, was Dr. Wollaston, to whom we owe many most valuable observations on the subject.

"I cannot," says he, "conclude these observations on dispersion, without remarking, that the colours into which a beam of white light is separable by refraction, appears to me to be neither seven, as they usually are seen in the rainbow, nor reducible by any means (that I can find) to three, as some persons have conceived; but that by employing a very narrow pencil of light,[2] four primary divisions of the prismatic spectrum may be seen with a degree of distinctness, that I believe has not been described nor observed before. If a beam of daylight be admitted into a dark room by a crevice $\frac{1}{20}$ of an inch broad, and received by the eye at the distance of ten or twelve feet through a prism of flint glass, *free from veins*, held near the eye, the beam is seen to be separated into the four following colours only, *red*, *yellowish green*, *blue*, and *violet*, in the proportions represented in the figure.

Fig. 85.



"The line A that bounds the *red* side of the spectrum is somewhat confused, which seems in part owing to the want of power in the eye to converge red light. The line B,

[1] *Edinburgh Phil. Journal*, vol. vi. p. 334, April 1822.

[2] See p. 406.

Prismatic Spectrum.

between red and green in a certain position of the prism, is perfectly distinct; so also are D, and E, the two limits of violet. But C, the limit of green and blue, is not so clearly marked as the rest; and there are also, on each side of this limit, other distinct dark lines, *f* and *g*, either of which, in an imperfect experiment, might be mistaken for the boundary of these colours.

"The position of the prism in which the colours are most clearly divided, is when the incident light makes about equal angles with two of its sides. I then found that the spaces AB,BC,CD,DE, occupied by them, were nearly as the numbers 16, 23, 36, 25." Dr. Wollaston adds, that when the inclination of the prism is altered so as to increase the dispersion of the colours, the proportions of them to each other are then also changed, so that the spaces AC and CE, instead of being as before 39 and 61. may be found altered as far as 42 and 58.

The lines which Dr. Wollaston has described in the preceding observations, are called the *fixed lines in the spectrum*, and may be considered, as we shall presently have reason to see, as one of the most valuable observations which have been made on this subject. He owed the discovery solely to his having used a *narrower* line of light, and had he employed a still narrower and brighter line, he would have seen many more lines.

In considering Dr Wollaston's observations, and comparing the results with those of Sir Isaac Newton, we must carefully attend to the circumstance, that he used *a beam of day-light*, not one of sun-light, and as this beam emanated from the blue sky, and was light which had been greatly modified by the action of the atmosphere, as we shall soon show, his estimate of the number and nature of the coloured spaces, does not in the least affect or invalidate the observations of preceding authors. The sun's light used by Newton had lost many of its rays, by the absorptive action of the atmosphere, before it fell upon Dr. Wollaston's prism. In consequence of taking it for granted that Dr. Wollaston was analysing the same kind of light that Sir Iasac Newton analysed, both he and Dr Young were misled in the interpretation of the phenomena. Speaking of the observations of Newton and his followers, Dr. Young says, "The observations were however imperfect, and the analogy was wholly imaginary. Dr Wollaston has determined the division of the coloured image or spectrum, in a much more accurate manner than had been done before: by looking through a prism, at a narrow line of light, he produces a more effectual separation of the colours, than can be obtained by the common method of throwing the sun's image on a wall. The spectrum formed in this manner consists of four colours only, *red*, *green*, *blue*, and *violet*, which occupy spaces in the proportion of 16, 23, 36, and 25, respectively, making together 100 for the whole length; the red being nearly one-sixth, the green and the violet each about one-fourth, and the blue more than one-third of the length. The colours differ scarcely at all in quality within their respective limits, but they vary in brightness; the greatest intensity of light being in that part of the green which is nearest to the red. A narrow line of *yellow* is generally visible at the limit of the red and green; but its breadth scarcely exceeds that of the aperture by which the light is admitted, and Dr. Wollaston attributes it to the mixture of the *red* with the *green* light. There are also several dark lines crossing the spectrum within the blue portion and in its neighbourhood, in which the continuity of the light seems to be interrupted. This distribution of the spectrum Dr. Wollaston has found to be the same whatever refracting substance may have been employed for its formation; and he attributes the difference, which has sometimes been observed in the proportion, to accidental variations of the obliquity of the rays."[1] Hence Dr. Young was led to suppose that the *yellow* line was the accidental union of the extremity of the *red* and *green* spaces,—to regard *yellow* as a mixture of *red* and *green* light, and to suppose that the *green space* consisted only of homogeneous green without any mixture of yellow. "In consequence," says he, "of Dr. Wollaston's *correction* of the description of the prismatic spectrum compared with these observations, it became necessary to modify the supposition that I advanced in the last Bakerian lecture respecting the proportions of the sympathetic fibres of the retina; *substituting* RED, GREEN, and VIOLET, for RED, YELLOW, and BLUE." In this manner the *yellow* space was struck out of the spectrum on the authority of Dr. Wollaston's observations!

Prismatic Spectrum.

2. *Discoveries of Fraunhofer.*

Discoveries of Fraunhofer.

Without knowing any thing of the discovery of fixed lines in the sky light by Dr. Wollaston, M. Fraunhofer, a celebrated practical optician at Benedictbaiern near Munich, made a series of the most beautiful discoveries respecting the spectrum, which he published in 1814 and 1815. By making use of prisms of uniform density, and entirely free of veins, and by excluding all extraneous light, and stopping the rays which formed the coloured spaces which he was not examining, he made the important discovery that the *solar* spectrum was covered with a great number of black lines of different thicknesses parallel to each other, and perpendicular to the length of the spectrum.

Lines in the spectrum.

All kinds of prisms, fluid or solid, provided they were good, exhibited the same lines, and Fraunhofer found, that these lines had a fixed position in the spectrum, and that they varied with the length of the spectrum, the distance between any two affording a precise measure of the action of the prism on the rays in which these two lines were placed. These lines are darker than the rest of the spectrum, and some of them appear entirely black. The largest lines could scarcely be seen if the aperture exceeded *a minute*, and the finest lines also disappeared entirely when the aperture was 40″. The aperture used by Fraunhofer was 36″ high, and 15″ wide, that is, at a distance of 24 feet from the aperture. It was nearly one-fiftieth of an inch wide, and 2.88 inches high. The prism was made of flint-glass, had a refracting angle of nearly 60°, and was placed before the object-glass of the telescope, so that the angles of incidence and emergence were equal, or the angle of refraction a *minimum*. This apparatus is shewn in fig. 1, Plate CCCLXXXI, where the prism is seen in front of the object-glass of the telescope of a repeating theodolite resting on a horizontal plane with a steel axis round which it moves. The box on which the axis turns is firmly united with the telescope.

Plate CCCLXXXI. Fig. 1.

When the prism was turned round, so as to increase the angle of incidence, the lines disappeared, and the same took place when the angle of incidence was diminished. But the lines reappeared at a greater incidence by shortening, and at a smaller incidence by lengthening the telescope.

The *solar prismatic spectrum*, as seen by Fraunhofer, is represented in fig. 2 of Plate CCCLXXXI which has been abridged, and many of the lines necessarily omitted, Fraunhofer himself, having been obliged to leave them out of his map. At the line A the *red* space nearly terminates, and the violet space at I; but when the light of an illuminated cloud fell upon the aperture in the prism, the spectrum appeared to terminate on one side at B, and on the other between G

Fig. 2.

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[1] Dr. Young has given in his Elements of Nat. Phil. vol. 1. p. 786, plate 29, a small coloured drawing of the spectrum as seen by Dr. Wollaston and himself, with the *yellow* line. This line has no existence in the true solar spectrum.

[2] Nat. Phil. vol. ii. p. 637.

Prismatic Spectrum.

and H. At A there is a distinct and well defined line, the boundary of the red space being a little beyond it. "At *a* there is a mass of lines, forming together a band darker than the adjacent parts. The line at B is very distinct, and of a considerable thickness. From B to C may be reckoned nine very delicate and well defined lines. The line at C is broad, and black like D. Between C and D are found nearly 30 very fine lines, which, however, with the exception of two, cannot be perceived but with a high magnifying power, and with prisms of great dispersion; they are besides well defined. The same is the case with the lines between B and C. The line D consists of two strong lines separated by a bright one. Between D and E we recognise about 84 lines of different sizes. That at E consists of several lines, of which the middle one is the strongest. From E to *b* there are nearly 24 lines. At *b* there are three very strong ones, two of which are separated by a fine and clear line. They are among the strongest in the spectrum. The space *b*F contains nearly 52 lines, of which F is very strong. Between F and G there are about 185 lines of different sizes. At G many lines are accumulated, several of which are remarkable for their size. From G to H there are nearly 190 different lines. The two bands at H are of a very singular nature. They are both nearly equal, and are formed of several lines, in the middle of which there is one very strong and deep. From H to I they likewise occur in great numbers, Hence it follows that, in the space BH, there are 574 lines. The relative distances of the strongest lines were measured with the theodolite, and placed in the figure from observation. The faintest lines only were inserted from estimation by the eye." The lines in the solar spectrum which we have thus minutely described after Fraunhofer, are not seen in the spectra formed by any white flame, or white light, whether it is generated by ordinary combustion, or produced by the application of intense heat to a solid body. In the flame of a lamp, however, Fraunhofer discovered that there is a double yellow line occupying *exactly* the same place as the double line D, the two black lines of D corresponding with the two luminous ones of the double yellow line in lamp light. Hence it follows that ordinary *white* light, produced in the manner already mentioned, has 590 rays of a definite refrangibility which do not exist in solar light, and hence the black lines have been called *defective rays* or *lines*.

Prismatic Spectrum.

"Various experiments," says Fraunhofer, "and changes to which I have submitted these lines, convince me that they have their origin in the nature of the light of the sun, and that they cannot be attributed to illusive observations, or any other secondary cause."

By means of the apparatus shewn in fig. 1, Plate CCCLXXXI, Fraunhofer determined in a very accurate manner the distances between the principal fixed lines[1] B, C, D, E, F, G, H, taking those which divided the spectrum most conveniently. The line *b* for example, would have been better than E for its magnitude and distinctness, but it does not divide the space DF so equally. He repeated these observations with different kinds of flint and crown glass of several fluids, and obtained the results given in the following table.

Table, shewing the Distances of the Principal Fixed Lines in the Spectrum, in various Media, according to Fraunhofer.

Different combinations of Refracting Media.	Temperat. Fahren.	Specific gravity.	Angle of the prism.	Angle of deviation.	BC	CD	DE	EF	FG	GH
	°		° ′ ″	° ′ ″	′ ″	′ ″	′ ″	′ ″	° ′ ″	° ′ ″
Flint glass, No. 13, ...	65¾	3·723	26 24 30	17 27 8	3 16	9 4·2	11 50	10 33·9	20 23·9	18 18
Crown glass, No. 9, ...	63½	2·535	39 20 35	22 38 19	2 44·5	7 23·5	9 14	8 14	15 10	13 18
Water, ...	65¾	1·000	58 5 40	22 36 40	3 24	8 10	9 58	8 38	15 16	12 41·9
Water, ...	65¼	1·000	58 5 40	22 36 40	3 12·4	8 10·6	9 57·5	8 30·5	15 15·6	12 46·2
Sol. of potash in water,	52¼	1·416	58 5 40	27 45 56	4 2	10 26	12 54	11 12	20 36	17 24
Oil of turpentine, ...		0·885	58 5 40	33 20 12	4 56	13 52	18 46·1	16 14	31 8	27 28
Flint glass, No. 3, ...		3·512	27 41 35	17 35 16·6	3 8	8 22	10 46	9 50	19 10	17 10
Flint glass, No. 30, ...		3·695	21 42 15	14 3 9	2 35·6	6 56·8	9 12·6	8 19	16 15·6	14 32·2
Crown glass, No. 13, ..		2·535	43 27 36	25 26 35·4	3 5	8 14·4	10 28·2	9 10	17 14·8	14 48·4
Crown glass, ...		2·756	42 56 40	26 39 13	3 32·8	9 37·6	12 29·8	11 1·6	20 53·6	18 17·4
Flint glass, No. 23, ...		3·724	60 15 42	49 55 13·2	11 12·6	31 14·8	41 21·4	38 14·8	1 14 45·2	1 8 3·6
Flint glass, No. 23, ...		3·724	45 23 14	32 45 12·2	6 26	17 47·8	23 31·8	21 23·8	41 33·4	37 28·8

These valuable data were deduced from measures taken *six* times for each substance; but as the theodolite was only twenty-four feet distant from the window of his dark room, it became necessary to apply a correction to the angle of deviation μ, arising from the distance 4·25 inches of the centre of the prism from the axis of the theodolite. This correction would have been very great for twenty-four feet, and therefore Fraunhofer, to avoid the uncertainty which

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[1] The reader will be desirous of knowing, which of these principal lines were discovered by Dr. Wollaston. The following attempt to do this is given by Sir David Brewster in his Report on Optics, published in the Proceedings of the British Association, vol. i. p. 320, note 2. In the spectrum formed by a narrow beam of day-light, Dr. Wollaston had previously to the year 1802, discovered *seven* lines, which he has designated by the letters A, B, *f*, C, *g*, D, E, the first line A being, according to his observations, the extreme boundary of the red rays, and the last line E the extreme boundary of the *violet* rays. The correspondence of these lines with those of Fraunhofer, I have with some difficulty ascertained to be as follows—

A, B, *f*, C, *g*, D, E Wollaston.
B, D, *b*, F, G, H. Fraunhofer.

There is no single line in Fraunhofer's drawing in the spectrum, (nor is there any in the real spectrum) coincident with the line C of Wollaston; and indeed he himself describes it as not being "so clearly marked as the rest." I have found, however, that this line C corresponds to a number of lines half way between *b* and F, which, owing to the absorption of the atmosphere, are particularly visible in the light of the sky near the horizon. In order to have seen the lines B and H of Fraunhofer, especially the last, Dr. Wollaston's "beam of day-light" must have come from a part of the sky very near the sun's disc.

Prismatic Spectrum.

arises from a great correction, determined the angle μ for the yellow ray of the light of a lamp which has the same refrangibility as D. When the lamp was placed at the distance of 692 feet, the correction of μ for crown glass and water was only 40″. Hence for the smaller arcs, which were really measured, the corrections were very small, being only 2″·5 for BC, 6″·5 for CD, and 8″ for DE. All the angular distances, therefore, in the preceding table have had this correction applied to them.

M. Fraunhofer then proceeded to determine the index of refraction m for the different fixed lines, and calling σ the angle of incidence, ρ the angle of emergence, ψ the angle of the prism, and m the index of refraction he obtained,

$$m=\sqrt{\left(\frac{(\text{sin. }\rho+\text{cos. }\psi\text{ sin. }\sigma)^2+(\text{sin. }\psi\text{ sin. }\sigma)^2}{\text{sin. }\psi}\right)}$$

When the angle of incidence is equal to the angle of emergence, or the angle of deviation a *minimum*, and if μ is the angle of deviation, or that which the emergent ray forms with the incident ray, we have

$$m=\frac{\text{sin. }\frac{1}{2}(\mu+\psi)}{\text{sin. }\frac{1}{2}\psi}.$$

When the dispersive power of the body under examination is very great, the value of the index of refraction m given by this last formula will not be rigorously correct, as the equality of the angles of incidence and emergence can only take place for one ray. Fraunhofer, therefore, measured the distances BC, CD, or when the distance of the two lines B and C, C and D was the smallest, which takes place when the ray or line which bisects these spaces has its angle of incidence and emergence equal. When the substances have a less dispersive power, or the prisms a smaller angle, the same care is not necessary to obtain this degree of accuracy. If we then call Em the index of refraction for the ray E, we have

$$\text{E}m=\frac{\text{sin. }\frac{1}{2}(\mu+\psi+\text{DE})}{\text{sin. }\frac{1}{2}\psi}.$$

and for the ray F,

$$\text{F}m=\frac{\text{sin. }\frac{1}{2}(\mu+\psi+\text{DE}+\text{EF})}{\text{sin. }\frac{1}{2}\psi}.$$

In this way Fraunhofer obtained the following indices of refraction for the different solids and fluids formerly used:—

Table, shewing the Indices of Refraction corresponding to the Principal Fixed Lines of the Spectrum, in various Media, according to Fraunhofer.

Refracting Media.	B m	C m	D m	E m	F m	G m	H m
Flint glass, No. 13,.....	1·627749	1·629681	1·635036	1·642024	1·648260	1·660285	1·671062
Crown glass, No. 9,.....	1·525832	1·526849	1·529587	1·533005	1·536052	1·541657	1·546566
Water,.....	1·330935	1·331712	1·333577	1·335851	1·337818	1·341293	1·344177
Water,.....	1·330977	1·331709	1·333577	1·335849	1·337788	1·341261	1·344162
Solution of potash in water,.....	1·399629	1·400515	1·402805	1·405632	1·408082	1·412579	1·416368
Oil of turpentine,.....	1·470496	1·471530	1·474434	1·478353	1·481736	1·488198	1·493874
Flint glass, No. 3,.....	1·602042	1·603800	1·608494	1·614532	1·620042	1·630772	1·640373
Flint glass, No. 30,.....	1·623570	1·625477	1·630585	1·637356	1·643466	1·655406	1·666072
Crown glass, No. 13,.....	1·524312	1·525299	1·527982	1·531372	1·534337	1·539908	1·544684
Crown glass,.....	1·554774	1·555933	1·559075	1·563150	1·566741	1·573535	1·579470
Flint glass, No. 23, prism of 60°,..	1·626596	1·628469	1·633667	1·640495	1·646756	1·658848	1·669686
Flint glass, No. 23, prism of 45°,..	1·626564	1·628451	1·633666	1·640544	1·646780	1·658849	1·669680

Illuminating power of the spectrum.

Before he proceeded to employ these results to the construction of achromatic telescopes, Fraunhofer endeavoured to determine by exact measurement the illuminating power of the spectrum at different points. In order to do this, he constructed an apparatus represented in figs. 3 and 4, Plate CCCLXXXI. To an eye-glass E, made on purpose for the telescope of the theodolite, he applied a small plane metallic mirror a, the edge of which being well defined, cut the field of the telescope in the middle, as shewn in the figure. It was placed at an angle of 45° to the axis of the object-glass A, and in its focus. The eye-glass E is pulled out till the edge of the small speculum a is distinctly seen. At the side of the eye-glass, and in a direction at right angles to the edge of the speculum a, or to the axis of the telescope, he fixed a tube bcB, cut at the point b in the direction of its length, and in this opening he placed a narrow and a shorter tube MN, whose section is seen at b, crossing the larger tube cB at right angles. A small flame, supplied with oil from an external vessel, was placed in the tube MN, so as to be in the axis of the tube cB. At the point of the narrow tube b or MN, where it was cut by the axis of the tube cB, was a small round aperture for allowing the light of the flame to fall upon the speculum a. Hence it follows that the eye at E will see in half of the field the speculum a illuminated by the flame, and in the other half the colours of the spectrum formed by a prism placed, as formerly described, before the object-glass A. By making the tube MN and the flame approach the speculum, we increase its degree of illumination, and can therefore make it equal to the illumination of the part of the spectrum which we wish to determine. In this way he obtained for each coloured space in the spectrum a certain distance of the flame from the speculum, which afforded a measure of the intensity of illumination, the squares of the distances being inversely as the intensities.

Plate CCCLXXXI.

"Though at first sight," says Fraunhofer, "it appears difficult to compare the light of two different colours, yet it becomes easy by a little practice. The intensity of the light of the mirror approaches more to that of any colour in the spectrum, if at the same position of the eye-glass its vertical margin is less distinct. If the mirror is adjacent to a part of the spectrum more or less illuminated, the edge of the mirror becomes, in both cases, more distinct; because, in the first case, the mirror appears to be placed in the shadow, and in the second case, it is the colour of the spectrum that is found there. The experiment with the mirror is a little difficult and uncertain, if we perceive clearly the lines of the spectrum, because the brightest and the darkest lines touch one another almost in every colour. On this account the aperture in the window-shutter is made so broad, that only the strongest lines are just visible, and the fine ones not at all. In place of the mirror outside of the shutter by which the light entered, I put a white plane surface illumi-

Prismatic Spectrum.

nated by the sun, because by any imperfection of the mirror the light is irregularly dispersed, which renders the observations more dubious.

"In order to vary the experiments, I at one time enlarged the round aperture before the flame, and at other times I contracted it. I placed also at the end *c* of the wide tube a piece of ground glass, through which the mirror received its light. In this case I measured the distances of the flame from the ground glass. To avoid all illusion, the aperture before the eye-glass ought to be small, and to be at the place where the principal rays, or the axes of the rays coming from the edge of the field, cut the axis of the telescope. With the prism of flint glass, No. 13, having an angle of 26° 24′ 5, I obtained the following results. Though the experiments were made in clear weather, and at noon, I sometimes perceived, in the course of the observations, a slight change in the density of the light which the prism received. The differences in the four sets of experiments may have been partly owing to this change, and the flame may also have changed its intensity in the course of the observations. If we call the intensity of the light at the brightest part of the spectrum 1, we shall then have,"—

Prismatic Spectrum.

Table, shewing the Intensity of Illumination at different points of the Spectrum.

Points of the Spectrum where the illumination was measured.	Intensity of light.	Intensity of light.	Intensity of light.	Intensity of light.	Mean Intensity, by four experiments.
At the line B,.....	0·0100	0·044	0·053	0·020	0·032
At ..... C,.....	0·0480	0·096	0·15	0·084	0·094
At ..... D,.....	0·6100	0·590	0·72	0·62	0·640
At 2-7ths of DE from E,.....	1·0000	1·000	1·00	1·00	1·000
At ..... F,.....	0·4400	0·38	0·61	0·49	0·480
At ..... F,.....	0·0840	0·14	0·25	0·19	0·170
At ..... G,.....	0·0100	0·029	0·053	0·032	0·031
At ..... H,.....	0·00110	0·0072	0·009	0·005	0·0056
	Exp. 1.	Exp. 2.	Exp. 3.	Exp. 4.	

Fraunhofer found the brightest part of the spectrum at the distance of nearly one-third or one-fourth of DE from D.

Plate CCCLXXXI.

The results of the preceding experiments are expressed in the curve, fig. 5, which accompanies the spectrum in fig. 2, the preceding values in the last column of the table being the ordinates of the curve, and the angular distances BC, CD, in the table in page 416, for flint glass, No. 13, being the abscissæ.

If we suppose that the quantity of the light in the differently coloured spaces is represented by the areas of the curves BC, CD, we shall obtain the following results, the area of the space DE being made equal to unity.

Quantity of light in, or area of,

BC.....0·021
CD.....0·300
DE.....1·000
EF.....0·328
FG.....0·185
GH.....0·035

Achromatic combinations.

M. Fraunhofer next proceeds to apply these interesting results to the construction of achromatic combinations for telescopes. From the results in the table in p. 416, he obtains the following ratios of the different dispersive powers of the differently coloured rays in the different combinations mentioned in the first column.

Table, shewing the Ratios of the Dispersion of the differently coloured rays for each combination of Media.

Refracting Media.	$\frac{Cn'-Bn'}{Cn-Bn}$	$\frac{Dn'-Cn'}{Dn-Cn}$	$\frac{En'-Dn'}{En-Dn}$	$\frac{Fn'-En'}{Fn-En}$	$\frac{Gn'-Fn'}{Gn-Fn}$	$\frac{Hn'-Gn'}{Hn-Gn}$
Flint glass, No. 13, and water,.....	2·562	2·871	3·073	3·193	3·460	3·726
Flint glass, No. 13, and crown glass, No. 9,.....	1·900	1·956	2·044	2·047	2·145	2·195
Crown glass, No. 9, and water,.....	1·349	1·468	1·503	1·560	1·613	1·697
Oil of turpentine and water,.....	1·371	1·557	1·723	1·732	1·860	1·963
Flint glass, No. 13, and oil of turpentine,.....	1·868	1·844	1·783	1·843	1·861	1·899
Flint glass, No. 13, and kali, ...	2·181	2·338	2·472	2·545	2·674	2·844
Kali and water,..	1·175	1·228	1·243	1·254	1·294	1·310
Oil of turpentine and kali,.....	1·167	1·268	1·386	1·381	1·437	1·498
Flint glass, No. 3, and crown glass, No. 9,.....	1·729	1·714	1·767	1·808	1·914	1·956
Crown glass, No. 13, and water,.....	1·309	1·436	1·492	1·518	1·604	1·651
Crown glass and water, ...	1·537	1·662	1·794	1·839	1·956	2·052
Crown glass, No. 2, and crown glass, No. 13,.....	1·174	1·171	1·202	1·211	1·220	1·243
Flint glass, No. 13, and crown glass,	1·667	1·704	1·715	1·737	1·770	1·816
Flint glass, No. 3, and crown glass,...	1·517	1·494	1·482	1·534	1·579	1·618
Flint glass, No. 30, and crown glass, No. 13,.....	1·932	1·904	1·997	2·061	2·143	2·233
Flint glass, No. 23, and crown glass, No. 13,.....	1·904	1·940	2·022	2·107	2·168	2·268

Prismatic Spectrum.

The important results embodied in the preceding table, completely overturn the opinion of Dr. Wollaston respecting the proportionality of the different colours, and establish beyond all question the *irrationality* of the coloured spaces. In the very first combination, for example, of *flintglass* and *water*, the ratio of the dispersion of the rays in the *red* space BC, is as 1 to 2·56, whereas in the *violet* space GH, it is as high as one to 3·726. In the combination of *flint glass* and *oil of turpentine*, we have a case where the irrationality is very trifling, and what Fraunhofer has not observed, the irrationality is nothing between the *orange* and *blue* spaces, and almost nothing between the *red* and *indigo*, but very considerable between the *green* and all the other spaces, and a maximum between the green and the violet. The differences of the ratios, too, are *negative* or diminishing in the two first or least refrangible spaces, and *positive* in all the rest, the *negative* differences nearly balancing the *positive* ones; whereas, with very trifling exceptions, the ratios increase towards the most refrangible extremity of the spectrum.

It is obvious that in the construction of achromatic object-glasses of flint and crown glass, there must always be a considerable portion of outstanding colours or *aberrations*, as Fraunhofer calls it. Hence in place of making the focal lengths of the two lenses in the exact ratio of their dispersive powers, we must alter the ratio so as to make the outstanding colours a minimum for the distinct vision of objects. But in order to do this, we must take into account the intensity of illumination in the coloured spaces; for it is obvious that a given irrationality in the yellow spaces, will, from the intensity of its illumination, be much more regarded than a similar irrationality in the violet space. As the outstanding rays, therefore, will be injurious to distinct vision in proportion to their intensity, the distinctness will be a maximum, as Fraunhofer has shewn, when the ratio of dispersion x is taken, such that

$$x=\frac{b\beta+c\gamma+d\delta+e\epsilon+f\xi+g\eta}{\beta+\gamma+\delta+\epsilon+\xi+\eta}$$

in which case we have

$$(x-b)\,\beta+(x-c)\gamma+(x-d)\delta+(x-e)\epsilon+(x-f)\xi+(x-g(\eta=0$$

where β, γ, δ, ϵ, &c. express the quantity of light in the spaces BC, CD, DE, &c. and b, c, d, e, &c. the quotients or ratios of dispersion $\frac{Cm'-Bm'}{Cm-Bm}$, $\frac{Dm'-Dm'}{Dm-Bm}$ &c.

This ratio, or the value of x calculated for *flint glass*, No. 30, and *crown glass*, No. 13, is as 1 to 2·012; but Fraunhofer found that in an object-glass, consisting of these two kinds of glass, the distinctness was a maximum when the ratio was as 1 to 1·98.

Fixed lines in star light.

To the Chevalier Fraunhofer we owe also the discovery of fixed lines in the light of the planets and fixed stars. As the light of our sun is defective in so many rays, it was to be expected that the light of all the planets which he illuminates, would be equally defective in the same rays. In the brighter colours of the *Moon's* spectrum, we find the same fixed lines as in the sun's light, and in the same place. The spectra from the light of *Mars* and *Venus* contained the lines D, E, *b*, and F, of solar light, and precisely in the same place. In the spectrum of *Sirius* he was unable to perceive fixed lines in the *orange* and *yellow* colours, but in the *green* he saw a very strong streak, and in the *blue* other two very strong ones, having no resemblance to any of the lines in the solar spectrum. *Castor* gives a spectrum resembling that of *Sirius*. The streak in the green was so intense, that notwithstanding the weakness of the light, yet he ascertained by measurement that it occupied the same place as the green streak in Sirius. He distinguished also the two streaks in the blue, but he could not ascertain their place. In the spectrum of *Pollux* he found many weak and fixed lines, which resembled those of *Venus*. The line D he saw distinctly, and occupying the same place as in the pure light. In the spectrum of *Capella*, he saw the lines D and *b*, as in solar light. The spectrum of *Betalgeus* contains numerous fixed lines, which in a favourable atmosphere are sharply defined. There were lines like the solar ones D and *b*. In the spectrum from *Procyon*, some lines were perceived with difficulty, but they were not sufficiently distinct to be measured. In the orange space, however, he saw a line at D.

Prismatic Spectrum.

Sect. VI.—*On the Physical Properties of the Spectrum.*

Physical properties of the spectrum.

The physical properties of the spectrum, which have been the subject of experimental investigation, are its *heating* power, and the *chemical* and apparently *magnetical* influence of its rays.

Heating power.

Heating power of the spectrum. That the heat of the coloured rays should be most intense where their light was strongest, was long the general belief of philosophers; and Landriani Rochon,[1] and Sennebier, found by direct experiment that the highest temperature existed in the *yellow* space. Sir W. Herschel, however, found that the heating power increased from the *violet* to the *red* space, and that the thermometer continued to rise when placed beyond the visible red extremity of the spectrum. He therefore drew the conclusion that there were invisible rays in the light of the sun which had the power of producing heat, and which had a less degree of refrangibility than red light. Sir W. Herschel attempted, in vain, to determine the index of refraction of the extreme invisible ray which possesses the power of heating; but he ascertained that at a point one-and-a-half inches distant from the extreme red ray, the invisible rays exerted a considerable heating power, even though the thermometer was placed at the distance of fifty two inches from the prism.

Sir W. Herschel.

In 1801, Sir Henry Englefield repeated these experiments; but he does not acquaint us with the kind of glass of which his prism was made. He obtained the following results, which confirm those of Sir William Herschel.

Sir Henry Englefield.

Colours of the Spectrum.	Temperature, Fahr.
Blue	56
Green	58
Yellow	62
Red	72
Beyond Red	79

From our author's own account of the method of making these experiments, we place no confidence in the principal result respecting the invisible rays. "*As I had nothing to do with light*," says he, "it was not necessary to darken the room; and as I wished to accumulate as large a portion of solar heat as possible, *I placed the prism in an open window*." As the whole interest of these experiments was concentrated in the determination of *invisible* heating rays, Sir Henry had a great deal to do with light, as the whole question turned upon an exact appreciation of the *termination of the spectrum*. In a dark room the spectrum is much longer than in open day, and we have reason to believe from experiment, that Sir Henry Englefield's spectrum did not visibly extend beyond the line C of Fraun-

[1] The Abbé Rochon used a prism of flint glass, and a thermometer containing spirits of wine, and he found the maximum temperature in the *yellow orange* rays. See his *Opsucules*, 1783.

Dr. Hutton, in his *Philosophy of Light and Heat*, Edin. 1794, p. 38. remarks that, "the compound light which is *white*, has a greater power of giving vision in proportion to its power of exciting heat; whereas in the *red* species, it is the opposite, for here the power of exciting heat is great in proportion to its power of giving vision."

Prismatic Spectrum

hofer, so that his maximum temperature of 79° was actually found in the red rays.

Recent experiments.

With the view of throwing light upon this subject, Sir David Brewster has endeavoured to ascertain the visible extent of the spectrum by various methods of condensing the light, and absorbing by coloured media, the luminous parts of the spectrum. By these means he has traced the visible spectrum, and the fixed lines in it as far beyond the line A as the distance of the group of lines *a* is from A, and has seen it indistinctly to a distance as great as AB beyond A. Hence there cannot be the least doubt that the experiments beyond the visible red were actually made when the thermometer was placed in the red space. He does not, however, conclude from this that there are no invisible rays beyond the red; but merely that the experiments of Herschel and Englefield were made in a part of the spectrum where rays of light actually exist. On the contrary, our author concludes that there are rays of heat of all degrees of refrangibility, and consequently consisting of waves of all degrees of breadth and velocity. When produced by a slight vibratory movement, the waves of heat are broad and slow; as the temperature rises they become narrower and quicker in their motion. When their velocity is such as to equal that of the extreme red ray, they become faintly visible, and the other colours are successively produced by quicker motion, till white light is radiated. This seems to be the process by which incombustible bodies are gradually raised from the deepest red to the brightest white; and if we examine, by means of a prism, the changes which take place in the gradually increasing light, we shall find that the different rays of the spectrum are successively added to the red light.[1] He conceives, therefore, that the sun emits rays of all degrees of refrangibility, extending probably far beyond the visible extremity of the violet, and though not capable of being rendered sensible, yet exercising powerful influences in the economy of nature.

Berard.

M. Berard, and Sir Humphry Davy obtained results analogous to those of Sir W. Herschel; M. Berard finding the maximum heat at the very extremity of the red ray, and Sir H. Davy beyond it.

Wunsch.

The most valuable series of experiments on this subject, were made by Professor Wunsch, and Dr. Seebeck of Berlin. So early as 1807, Professor Wunch[2] had made experiments with *prisms* of various substances, and obtained the following results:

Substances of which the Prisms were made.	Place of maximum heat.
Alcohol	Yellow space.
Oil of turpentine	Yellow space.
Water	Yellow space.
Green glass	Red.
Yellow glass	Extreme red.

Seebeck.

These results were confirmed by Dr. Seebeck, who obtained the following new results:

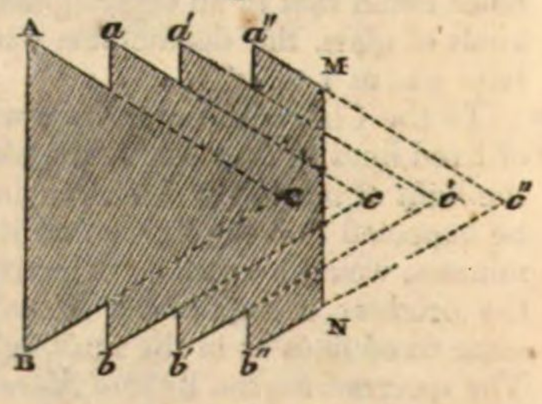
Substances of which the prisms are made.	Place of maximum heat.
Sulphuric acid concentrated	Orange.
Solution of sal-ammoniac	Orange.
Solution of corrosive sublimate	Orange.
Crown glass	Middle of red.
Plate glass	Middle of the red.
Flint glass, English	Beyond the red.
Flint glass, Bohemian	Beyond but nearer the red

The explanation which was given of these results, (which had been ascribed to different prisms of refracting caloric,[3]) by Sir David Brewster, accounts in a very satisfactory manner for all the phenomena. He conceives that transparent bodies have the same power of absorbing or stopping certain rays of the thermometric spectrum, as Dr. Robison called it, in the same manner as *coloured* bodies have the power of stopping certain rays of the luminous spectrum. These last bodies necessarily became coloured by stopping certain rays; but as the eye is not sensible to heat in the same manner as to light, the absorptive power of transparent bodies for heat can only be proved by the thermometer. He considers *water* as the type of bodies which are uniformly transparent for heat, as its maximum of heat coincides with its maximum of light. A prism of crown glass, on the contrary, is less uniformly transparent for heat; and its maximum of heat is in the red space, because it has absorbed much of the heat in the yellow space. In like manner flint glass has absorbed more of the heating rays in the red than the crown glass, and hence its maximum is about the extremity of the red, or beyond the end of the spectrum as commonly seen. In coloured media the maximum ordinate of their luminous spectrum, shifts along the whole prismatic spectrum; sometimes there are *two* or *more maxima* of light, and sometimes narrow and wide spaces entirely defective in light. Hence Sir David Brewster[4] supposes that there are defective spaces, and lines in the thermometric spectrum.

Prismatic Spectrum.

This view of the subject suggests a new mode of investigating the phenomena of the heating rays. If we take a prism of coloured glass to investigate the dark spaces and lines produced by absorbing media, we shall only have a very imperfect approximation to the true result; that is, we never could have absolutely dark spaces in the spectrum, as long as all the rays that went to the formation of the spectrum, passed through *all the different thicknesses of the prism.* The thinnest parts of the prism allow all the rays to pass, and consequently illuminate the whole spectrum, so that the actions of various thicknesses of the media are confounded, and the real absorptive action at a given thickness concealed. In like manner in the spectrum of heat, the heating rays which pass through the thin parts of the prism, will throw heat into every part of the spectrum; and hence the experiments should be made with the frustums of prisms, where the difference of thickness is small, and the want of area made up by an increased height of the prism. The best way, however, of making the experiments, would be to use a compound prism constructed as in the annexed figure, where AB, MN, is the section of a compound prism consisting of four frusta of prisms, AB, *ab*, *a'b'*, &c. the frustum AB, being part of a prism ABC. the frustum *ab*, part of a prism *abc*, &c. or this compound prism, in place of being ground out of the mass, which would be difficult though practicable, might be composed of a single prism ABC, with parallel plates of the same glass added by cement so as to compose the notched parallelogram ABMN. Very interesting results might also be obtained by using spectra formed by interferences in the manner we shall afterwards describe.

Fig. 86.



In all experiments with fluid prisms, the results are perplexed with the effects of the plates of glass by which the prisms are confined, in the same manner as we would disturb and indeed nullify the results respecting the absorption of light

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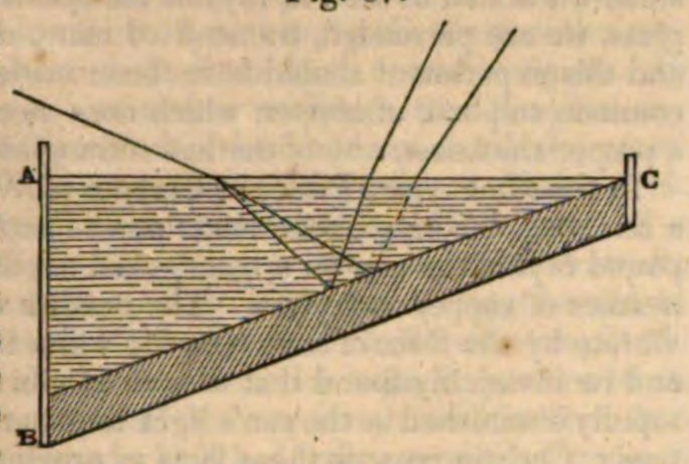
[1] See Professor Powell's valuable *Report on Radiant Heat, British Association Reports*, vol. i. p. 295. [2] *Magazine der Gesellsch.* &c.
[3] Turner's *Chemistry*, 3d Edit. p. 84. [4] Professor Powell's *Report*, p. 293, 294.

Prismatic Spectrum.

by coloured fluids, were we to confine them in hollow prisms made of coloured glass. The only method of remedying this defect in the experiment, would be to form the spectrum by a prismatic vessel of the fluid, whose upper surface AC, is formed by gravity, and its lower surface BC, by a plate of highly polished silver, which reflects back the spectra through the first surface.

Fig. 87.



According to Berard's experiments, the calorific rays of the spectrum are capable of being doubly refracted and polarised like those of light, and he obtained the same result with culinary heat;—the heat of a dark body below redness, being substituted for solar heat.[1]

Chemical effects of the spectrum.

On the chemical effects of the spectrum. It was long ago observed by Scheele that muriate of silver was rendered much blacker in the violet rays of the spectrum, than in any other part of it.[2] In the year 1801, Professor Ritter of Jena exposed muriate of silver in various parts of the spectrum, and also beyond its apparent limits. He found that the action was least of all in the red rays, greater in the yellow, greater still in the blue and violet, and greatest of all beyond the *visible* violet rays. Dr. Wollaston and M. Beckman obtained a similar result, apparently without knowing what had been done by Ritter. In repeating the experiments of Scheele with white muriate of silver, "he found that the blackness extended not only through the space occupied by the violet, but to an equal degree, and to about an equal distance, beyond the visible spectrum; and that by narrowing the pencil of light *the discoloration may be made to fall* ALMOST ENTIRELY beyond the violet. It would appear, that this and other effects usually attributed to light, are not in fact owing to any of the rays usually perceived, but to *invisible* rays that accompany them; and that if we include two kinds that are invisible, we may distinguish upon the whole *six* species of rays into which a sunbeam is divided by refraction."[3]

Muriate of silver.

The phrase *almost entirely* beyond the violet, used by Dr. Wollaston, cannot be considered as indicating the existence of invisible rays, even if we did not know from the experiments of Fraunhofer and others, that the visible violet space extends greatly beyond the place where both Ritter and Wollaston found the muriate of silver to be blackened. The existence of invisible rays, therefore, however probable, cannot be regarded as a scientific fact.

Gum guiacum.

The chemical action of the least refrangible rays upon gum guiacum was discovered by Dr. Wollaston. Having washed a card with a solution of this gum in alcohol, he found that it acquired a *green* colour from the concentrated violet and blue rays. No change of colour was effected by heat; but in the red rays the tinged card lost its *green* and recovered its original colour. When the tinged card was placed in carbonic acid gas, the violet rays could not make it green; but when made green as before, it was speedily restored to its original yellow colour by the red rays. As Dr. Wollaston found that the back of a heated silver spoon restored the green colour as well as the red rays, we cannot attach any definite meaning to these experiments.

Prismatic Spectrum.

Hydrogen andchlorine

MM. Gay Lussac and Thenard discovered a very energetic chemical action of the solar rays. On exposing to a pencil of solar light, a mixture of hydrogen gas and caloric, in equal volumes, a detonation of the mixed gases took place, and hydrochloric and (muriatic acid) was formed.

M. Berard.

M. Berard repeated the experiments with muriate of silver, and with the preceding mixture of gases which he placed in the different coloured spaces of the spectrum, and he found that the chemical action was in every case more powerful towards the violet extremity and a little beyond it. M. Berard likewise concentrated the least refrangible half of the spectrum by means of a lens, and then the most refrangible half. The latter, though the most intense, produced no effect upon the muriate of silver, but the former blackened it in less than ten minutes.[4]

Mrs. Somerville.

Mrs. Somerville,[5] found that the chemical rays passed as freely through blue glass coloured with cobalt, as through colourless glass. Having dipped a piece of paper in a solution of muriate of silver, and cut it into two parts, one of them was placed under a blue glass, and the other under a white glass at the same instant. The one did not become black more than the other, and there was no difference in the intensity of their colour.

Dr. Young.

Dr. Thomas Young made a very interesting experiment with the view of determining if the invisible chemical rays interfered with the luminous ones. He produced the Newtonian rings with a thin plate of air, and having formed an image of them by means of the solar microscope, he threw this image upon paper dipped in a solution of nitrate of silver, and placed it at the distance of about nine inches from the microscope. "In the course of an hour," says he, "portions of three dark rings were very distinctly visible, much smaller than the brightest rings of the coloured image, and coinciding very nearly, in their dimensions, with the rings of violet light that appeared upon the interposition of violet glass. I thought the dark rings were a little smaller than the violet rings, but the difference was not sufficiently great to be accurately ascertained. It might be as much as one-thirtieth, or one-fortieth of the diameter, but not greater."[6]

M. Arago.

A more decisive experiment was afterwards performed by M. Arago, who formed a set of fringes, by the interference of two solar pencils, proceeding from a common origin, and having kept them very steadily for a long time upon the same part of a piece of paper rubbed with muriate of silver, a series of black lines were traced upon leaving their intervals, smaller than those of the dark and bright fringes formed by violet light.

Sir John Herschel.

In the summer of 1831, we had the satisfaction of being shewn by Sir John Herschel a very interesting experiment on the chemical action of the violet rays. When a solution of platinum in nitro-muriatic acid[7] is mixed with lime water, no precipitation to any considerable extent takes place in the dark, a slight flocky sediment only being formed after long standing. But if a fresh mixture, or an old one cleared by subsidence of this sediment, is exposed to the sun's rays, it instantly becomes milky, and a *white* precipitate is copiously formed. If the solution of platina is in excess, the precipitate is of a pale yellow colour. In the common light of a cloudy day, the same effect is produced more slowly. When tubes containing the mixture are exposed within red fluids, or even yellow ones which absorb the violet rays, no precipitation takes place.[8]

The following remarkable facts were published in the *Journal de Pharmacie* for March 1832, but the abstract

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[1] *Mem. de la Societé d'Arcueil*, 1817, tom. iii. A full account of these experiments, occupying a whole chapter of eighteen pages, will be found in Biot's *Traité de Physique*, tom. iv. p. 600.

[2] *Traité de l'Air et du Feu*, § 66.

[3] *Phil. Trans.* 1802.

[4] *Biot's Traité de Physique*, tom. iv. p. 673, 674.

[5] *Phil Trans.* 1826, part ii. p. 136.

[6] *Elements of Nat. Phil.* vol. ii. p. 647

[7] The excess of acid must be neutralised by the addition of lime, and the solution well cleared by filtration.

[8] See *Lond. and Edin. Phil. Mag.* No. 1, July 1832, p. 58.

Prismatic Spectrum.

from which we quote them, does not mention the name of the author.[1] A solution of peroxalate of iron, when kept in the dark or exposed to the heat of boiling water, suffers no change; but if it is exposed to the sun's rays, an infinite number of bubbles of carbonic acid are disengaged, and the solution is like a syrup undergoing strong fermentation.

A solution of muriate of platinum is decomposed by the oxalic acid, and the oxalates by the sun's light, with almost as energetic a disengagement of gas as the solution above mentioned.

Muriate of gold, when reduced by oxalic acid through the agency of light, covers the interior surface of the vessel with an uniform brilliant gilding, which is of a pure green colour by reflected light.

Oxalate of silver under water, is partially decomposed by solar heat (not by culinary heat) into metallic silver and carbonic acid. If the reddish brown solution of muriate of iridium in water, mixed with oxalic acid and heated to ebullition, is exposed to the sun, total discoloration promptly takes place, carbonic acid is disengaged, and grey metallic iridium precipitated.

Magnetic influence of the solar rays.

Magnetic influence of the solar rays.—Though many interesting and apparently accurate experiments have concurred to indicate the existence of this property of light, yet recent inquiries have thrown a considerable doubt upon the conclusions which have been drawn from them. Dr. Morichini, a Roman physician, first succeeded in 1813, in magnetising small needles, by making a focus of the violet rays, collected by a lens, pass repeatedly from the middle to one end of a needle, without touching the other half. By continuing this process for an hour, the needle had acquired distinct polarity. This experiment was repeated successfully by the Marquis of Ridolfi and M. Carpa; and Sir H. Davy and Professor Playfair, and other English philosophers, witnessed the successful performance of this experiment. Professor Configliachi at Rome, with the benefit of an Italian sun, M. Berard of Montpellier, and M. Dhombre Firmas at Alais, failed in obtaining similar effects from the violet rays, and hence the doctrine of the magnetic efficacy of blue light was exploded both by the French and Italian philosophers.

Mrs. Somerville.

In 1825 Mrs. Somerville repeated, in a different way, the experiments of Morichini. She took a slender sewing needle an inch long, quite devoid of magnetism, and having covered half of it with paper, she fixed it to the pannel of the wall with wax, so that its uncovered half should receive the violet rays of a spectrum formed by an equianglar prism of flint glass, whose refracting faces were each 1·4 by 1·1 inches, and which was placed about five feet from the wall. The needle was placed in a vertical plane nearly perpendicular to the magnetic meridian, and inclined to the horizon, and as the sun advanced to the meridian, the needle was moved parallel to itself to keep it in the sun's rays. In less than two hours, when the sun had just passed the meridian, the exposed half of the needle attracted the south and repelled the north pole of the magnetic needle. A second experiment on the same day confirmed this result, and similar effects were obtained by varying the circumstances of the experiment.

In the blue and green rays, the needles were magnetised but less frequently, and always after a longer exposure, but the magnetism was always as strong as in the violet. The indigo rays were nearly as efficacious as the violet. Pieces of clock and watch spring were also magnetised after longer exposure, and magnetic needles had their magnetism increased by the same means. When the violet rays were concentrated with a lens, the magnetism was sooner conveyed to the needle. When the halves of the needles and the pieces of spring were enveloped in violet and green silk, they became magnetic also. Mrs. Somerville does not seem to have tried as a check upon these results, the action of the *red* rays of the spectrum. The blue glass, we are persuaded, transmitted many of the red rays, and this experiment should have been made by using the common sulphate of copper, which does not transmit, with a proper thickness, any of the less refrangible rays.[2]

Prismatic Spectrum.

Professor Christie.

In the same year, Professor Christie of Woolwich, made a series of elaborate experiments on the action of the compound rays of the sun on a magnetised needle, and also on needles of copper and glass. The needles were caused to vibrate by the force of torsion in the white light of the sun, and he invariably found that the arc of vibration was more rapidly diminished in the sun's light than in the shade. Professor Christie regards these facts as proving incontestibly the existence of a magnetic influence in the solar rays, and tending to restore the credit of Morichini's experiments. He intended to make his needles vibrate under the separated rays of the sun, and had an apparatus prepared for the purpose; but we are not aware of his having either made these experiments or published any account of them.[3]

Baumgartner.

M. Baumgartner of Vienna,[4] while repeating the experiments of Mrs. Somerville, found that a steel wire, some parts of which were polished, while the rest were rough or without lustre, were magnetised by the action of the white light of the sun, each polished part exhibiting a *north*, and each unpolished part a *south* pole. By concentrating the sun's rays, the effect was produced more rapidly. On a wire eight inches long, he thus obtained eight poles. When the needles were perfectly oxidated or perfectly polished, or had polished lines in the direction of their lengths, he could not succeed in magnetising them.

Barlocci.

A less equivocal method of proving the magnetic influence of white light presented itself to Professor Barlocci. An armed natural loadstone capable of carrying a weight of $1\frac{1}{2}$ Roman pounds (a Roman lb. is equal to 339·179 grammes) after *three hours* exposure to the strong light of the sun, was able to carry 2 oz. or one-sixth of a lb. more, and after an exposure of 24 hours its force was almost *doubled*. A second loadstone of nearly the same power was put into a dark place of the same temperature as that of the solar rays, but acquired no additional strength. A stronger magnet, which carried 5 lbs. 5 oz. and 2 deniers, was exposed to the light of a cloudy and humid atmosphere, and where it snowed; but it acquired no additional power; while, during the two subsequent days under a clear sky, its energy was more than doubled. The effect was not increased by a lengthened exposure.

Zantedeschi.

Among the most active labourers in this department of science, we must rank M. Zantedeschi of Pavia.[5] He had early obtained results similar to those of Morichini, and about the end of 1825, he had remarked, that suspended wire needles, devoid of all magnetism, and having one of their ends exposed to the white light of the sun under a glass receiver, turned that extremity to the north in the plane of the magnetic meridian. In repeating the experiment of Barlocci with artificial magnets, M. Zantedeschi found that a horse-shoe magnet, carrying $13\frac{1}{3}$ ounces, carried $3\frac{1}{2}$ oz. more after three days exposure to the sun, and by continued exposure, was able to carry 31 oz. He found also that the strength of oxidated magnets was increased by solar light, and that it diminished in those that were not oxidated. A loadstone, for example, not oxidated, lost $2\frac{1}{2}$ oz. of its strength by three hours exposure to solar light, whilst another oxidated and similarly exposed, gained as much and even more strength. When the first was polished like a mirror, its strength suffered no change by a prolonged exposure to the

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[1] *Id. Id.* June 1832, p. 466. [2] *Phil. Trans.* 1826. p. ii. p. 132. [3] *Id. Id.* p. 219—239. [4] *Zeitscrift*, tom 1. p. 263.
[5] *Edinburgh Journal of Science*, No. V. N.S. 1830, p. 76.

Prismatic Spectrum.

sun. He likewise found that when a loadstone, whether oxidated or not, had its *north pole* exposed to the sun, it *acquired strength*, but *lost strength* when its south pole was exposed. In more than sixty experiments, the increase of strength varied from 1 to 2, and to $3\frac{1}{2}$ oz. whereas the corresponding diminution was from $3\frac{1}{2}$ to 5, and to $5\frac{1}{2}$ oz. In these experiments our author confesses that he often encountered anomalies of which he could not detect the cause.

In repeating the experiments of Professor Christie, M. Zantedeschi obtained analogous results. Having placed a magnetic needle a foot long *in the shade*, he drew its place of rest through an arch of 90°, and it performed in 30″ four oscillations, the last of which had a semi-amplitude of 70°. When exposed *to the solar rays*, it performed in the same time, and under the very same circumstances, four oscillations, the last of which had only a semi-amplitude of 60°.

Riess and Moser.

A great degree of doubt has been cast upon the conclusiveness of all these researches, by a series of well-managed experiments made recently by MM. Riess and Moser. The following experiments were made after the manner of Morichini. The needles were made of soft steel; their mass was very small, and they presented a considerable surface to the action of the light. The prism was placed in the position of minimum deviation, which corresponds to the greatest intensity of the light of the spectrum, the needles were placed on a graduated circle, three or four feet from the prism. The lens used had an aperture of 1·2 inches, and a focal length of 2·3 inches, and by it the focus of the violet rays was made to traverse one-half of the needle 200 times, excepting on the 10th July and the 12th August, when it was done only 100 times, and on the 25th July, when it was done 525 times. The following were the results which they obtained, shewing no change in the number of oscillations.

Dates.	Names of the Needles.	Duration of Oscillations. Before experiment.	After experiment.	Time of Observation.
April 3,	*a*	22″·0	22″·0	$10\frac{1}{2}$ 12
—— 27,	*b*	27 ·5	27 ·5	$9\frac{1}{2}$ 11
	c	14 ·5	14 ·5	$9\frac{1}{2}$ 11
May 6,	*d*	3 ·0	3 ·0	$8\frac{1}{2}$ 10
June 14,	*e*	15 ·2	15 ·7	9 12
—— 16,	*f*	22 ·0	22 ·0	$9\frac{3}{4}$ $11\frac{3}{4}$
—— 17,	*f*	22 ·7	22 ·5	$8\frac{3}{4}$ $11\frac{3}{4}$
—— 23,	*g*	18 ·2	18 ·2	9 $10\frac{3}{4}$
July 1,	*f*	23 ·0	23 ·7	$9\frac{1}{4}$ $12\frac{1}{4}$
——,	*h*	19 ·5	19 ·5	$9\frac{1}{4}$ $12\frac{1}{4}$
—— 11,	*f*	22 ·4	22 ·2	$8\frac{1}{2}$ $10\frac{3}{4}$
——,	*i*	27 ·7	22 ·5	$8\frac{1}{2}$ $10\frac{3}{4}$
—— 25,	*f*	19 ·5	19 ·2	$9\frac{1}{4}$ 11
Aug. 10,	*f*	22 ·0	22 ·2	9 12
——,	*k*	20 ·2	20 ·0	9 12
—— 12,	*f*	22 ·2	22 ·2	9 $11\frac{1}{2}$
——,	*l*	17	16 ·7	9 $11\frac{1}{2}$

As *reflected* light was not used in Morichini's experiments, which our author wished to verify, they employed the *direct* light of the sun. In the experiments, however, with the needles *a*, *b*, *c*, they fixed the spectrum by means of a heliostate. They remark that the needle had been exposed $17\frac{1}{2}$ hours to the action of the sun without becoming magnetic, whereas Morichini succeeded in magnetising his needles in from fifteen to thirty minutes.

These gentlemen repeated also in a similar manner the experiments of Baumgartner, but it would be unprofitable to detail them here, as they could not reproduce any of the results which he had obtained. They tried also the action of polarised light, but without any better success.[1]

SECT. VII.—*Recent Discoveries respecting the Spectrum.*

Prismatic Spectrum.

New analysis of the spectrum.

The analysis of white or compound light by the prism was made and perfected by Sir Isaac Newton; but though the prism could not decompose them, he committed a mistake in concluding that the colours of the spectrum were simple and homogeneous; "that to the same degree of refrangibility ever belonged the same colour, and to the same colour ever belonged the same degree of refrangibility." Now, though it is quite true that the *green* and *orange* colours of the spectrum cannot be decomposed *by the prism* into more simple ones, the one into *blue* and *yellow*, and the other into *yellow* and *red*, yet they can be decomposed by other means. This opinion respecting the compound nature of the colours of the spectrum, and the inability of the prism to analyse them, was first maintained by Sir David Brewster,[2] who, with the view of placing it beyond a doubt, undertook a series of experiments, in which he examined the effects produced on the solar spectrum by viewing it through a great number of coloured media, and reflecting it from coloured. By these experiments, he not only established the accuracy of his first opinion, that the *green* and *orange* colours of the spectrum were compound, the one consisting of *blue* and *yellow*, and the other of *red* and *yellow*, but was led to the more general result, that the whole spectrum was compound, consisting of three equal and superposed spectra of *red*, *yellow*, and *blue* light.[3] The following are the general results which he obtained:—

"1. White light consists of *three* simple colours, *red*, *yellow*, and *blue*, by the mixture of which all other colours are formed.

"2. The solar spectrum, whether formed by prisms of transparent bodies, or by gratings or grooves in metallic and transparent surfaces, consists of *three* spectra of *equal length beginning and terminating at the same points*, viz. a *red* spectrum, a *yellow* spectrum, and a *blue* spectrum.

"3. All the colours in the solar spectrum are *compound* colours, each of them consisting of *red*, *yellow*, and *blue* light in different proportions.

"4. A certain quantity of *white light*, incapable of being decomposed by the prism, in consequence of all its component rays having the same refrangibility, exists at every

Fig. 88.

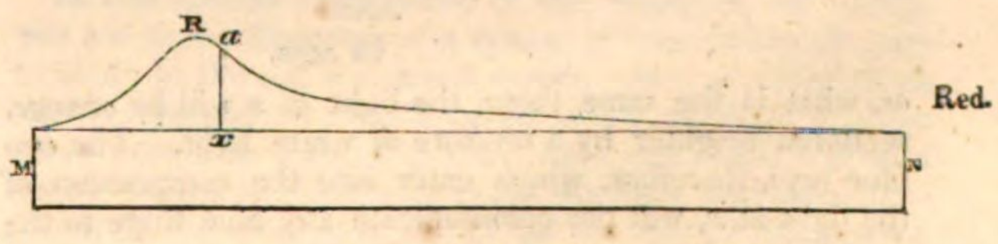


Fig. 89.

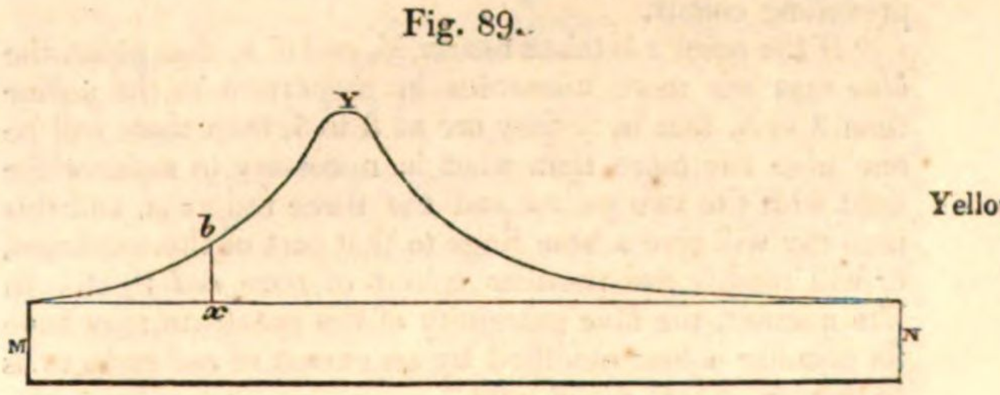
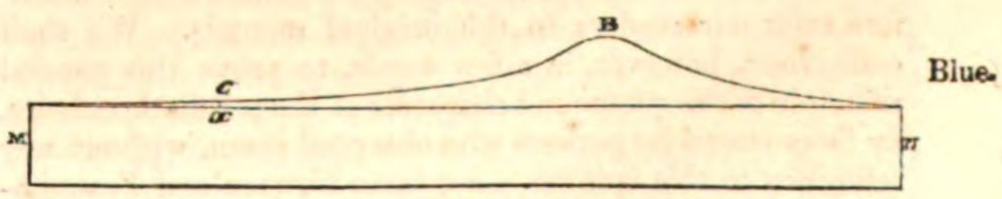


Fig. 90.



[1] See *Annales de Chimie*, 1829.

[2] *Edinburgh Transactions*, vol. ix. p. 48.

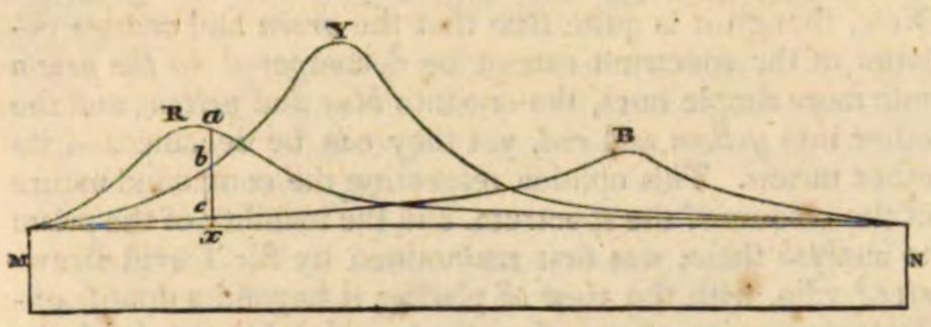
[3] *Id. Id.* vol. x. p. 123.

Prismatic Spectrum.

point of the spectrum, and may, at some points be exhibited in an insulated state.

"This remarkable structure of the spectrum will be better understood from figs. 88, 89, 90, which represent the three separate spectra, which are shewn in their combined state in fig. 91.

Fig. 91.



"In all these figures, the point M corresponds with the *red*, or *least refrangible* extremity of the spectrum, and N with the *violet* or *most refrangible* extremity; and the ordinates *ax*, *bx*, *cx*, of the different curves MRN, MYN, MBN, represent the intensity of the *red*, *yellow*, and *blue* ray at any point *x* of the spectrum.

"If the distance M*x* in all these spectra be equal, then, in the combination of them shewn in fig. 91, the ordinates *ax*, *bx*, *cx*, will indicate the nature and intensity of the colour at any point *x* of the red spectrum. Thus, let

"The ordinate for *red* light $ax=30$,
yellow $bx=16$,
blue $cx=2$,

$ax+bx+cx=48$ rays,

then the point *x* will be illuminated with 48 rays of light, viz., 30 of red, 16 of yellow, and 2 of blue light.

"Now, as there must be certain quantities of red and yellow light which will form white, when combined with two blue rays, let us assume these, and suppose that white light, whose intensity is 10, will be formed by 3 red, 5 yellow, and 2 blue rays; hence it follows that the point *x* is illuminated by

"Red rays,.....27
Yellow rays,.....11
White light,.....10

48 rays,

or, what is the same thing, the light at *x* will be *orange*, rendered brighter by a mixture of white light. The *two* blue rays, therefore, which enter into the composition of the light at *x*, will not communicate any blue tinge to the prevailing colour.

"If the point *x* is taken nearer M, and if, at that point, the *blue* rays are more numerous in proportion to the *yellow* than 2 to 5, that is, if they are as 3 to 5, then there will be one blue ray more than what is necessary to make white light with the two yellow and the three red rays, and this blue ray will give a blue tinge to that part of the spectrum, or will modify the peculiar colour of *pure red* light. In like manner, the *blue* extremity of the spectrum may have its peculiar colour modified by an excess of *red* rays, so as to convert it into *violet* light."

It would occupy too much space to bring forward the body of evidence which supports these views, and we must therefore refer our readers to the original memoir. We shall endeavour, however, in a few words, to prove the general principle of the compound character of the prismatic colours, by facts stated by persons who observed them, without any reference to this opinion. Sir Isaac Newton and Fraunhofer, and many persons besides, have, from long observation of the solar spectrum, concluded that there is a *homogeneous unmixed yellow*, and a *homogeneous unmixed orange* space in the spectrum. Newton makes the *yellow* space 40, and the *orange* 27, or 67 in all; while Fraunhofer makes the *yellow* space 27, and the *orange* space 27, or 54 parts of a spectrum whose length is 360 parts. Now, Dr. Wollaston declares that a beam of daylight is refracted by the prism into *five colours* ONLY, *red*, *yellowish green*, *blue*, and *violet*, and he defines their limits with his usual accuracy. Dr. Young, who repeated the same experiments with that exactness which was peculiar to him, declares that the spectrum formed in Dr. Wollaston's manner, consists of *four colours* ONLY, *red*, *green*, *blue*, and *violet*, "the colours differing scarcely at all in quality within their respective limits." Now both these accurate observers have rejected the *yellow* and *orange* spaces almost entirely, with the exception of the narrow line of yellow light formerly mentioned, thus running counter to all the observations of Newton and Fraunhofer. The cause of such a difference is this: The light analysed by Wollaston was the *blue light of the sky*, which had been deprived by absorption of many of its rays, having the same refrangibility as those which fell upon the prism. Dr. Young's *green* space was Sir Isaac Newton's *yellow* space, deprived of most of its *yellow* rays, and the *red* space adjoining the green was Newton's *orange* space, deprived by the absorption of the atmosphere, of almost all its yellow rays; and the sharp yellow line noticed by Dr. Young, and regarded by Dr. Wollaston as a mixture of red and green light, as if these spaces had overlapped a little, is part of the *orange* space of Fraunhofer and Newton, deprived of its *red* rays. This *yellow* band can be produced artificially upon all kinds of white light, and by the absorption of various media. Hence it is obvious, that by comparing the light reflected and modified by the *blue sky* with the direct *light of the sun*, we may obtain irrefragable proof of the compound nature of the yellow and orange spaces. That *red* light exists at the most refrangible extremity, is obvious from its *violet* colour; and that *blue* light exists at the *red* extremity, may be proved by the following observation of Sir W. Herschel.[1] He had occasion to view the prismatic spectrum, when reflected from clear turned brass, and he observes, "The colour of the brass *makes the red rays appear like orange*, and *the orange colour is likewise different from what it ought to be*." Here then, yellow light was seen at the very red end of this spectrum, and it was seen in consequence of *blue* light having been absorbed by the brass, because *blue* light mixed with the *orange*, observed by Sir W. Herschel, would alone recompose the original red. Here, then, there is a proof that *blue* light, and *yellow* light, and *red* light, all exist in the same place, at the least refrangible end of the spectrum. Effects similar to these may be produced by various coloured media, such as chemical solutions, or the coloured juices of plants; and by such means Sir David Brewster has succeeded *in insulating white light in the spectrum, incapable of being decomposed by the prism*. In a more recent memoir, "On the connexion between the phenomena of the absorption of light and those of thin plates,"[2] he has shewn that a separation of rays of different colours but equal refrangibility, is effected by the continued production of periodical colours by a number of thin plates acting successively upon the same pencil.

The existence of fixed lines in the spectrum, as discovered by Fraunhofer, was a fact unexampled in science. Various coloured bodies were known to absorb particular parts of the spectrum, and their peculiar colour was the necessary consequence of this absorption. Some of them, such as smalt blue glass, produced at a certain thickness several dark bands in the spectrum, but these bands shaded off by

[1] *Phil. Trans.* 1800, vol. xc. p. 255.

[2] *Id. Id.* 1837.

Prismatic Spectrum.

imperceptible degrees, and had no definite boundary.[1] In examining the action of all the coloured solid and fluid bodies which he could command, Sir David Brewster was led to observe the action of nitrous acid gas on the spectrum.[2]

Action of nitrous acid gas on the spectrum.

With a fine prism of rock salt, having the largest possible refracting angle, he formed a spectrum with the light of a lamp transmitted through a small thickness of the gas, whose colour was a very pale straw yellow, and he was surprised to observe the spectrum crossed with hundreds of lines or bands, much more distinctly pronounced than those of the solar spectrum. In the violet and blue spaces the lines were sharpest and darkest; they were fainter in the green, and almost imperceptible in the yellow and red spaces. By an increase in the thickness of the gas, the lines were better developed in the yellow and red spaces, and became broader in the blue and violet, a general absorption or extinction of the light advancing from the violet extremity, while a specific absorption was going on, on each scale of the lines or bands. It was not easy to obtain a sufficient thickness of gas to bring out the lines at the red extremity, but our author found that heat produced the same effect as an increase of thickness, and by greatly heating a tube half an inch wide, and full of gas, he was able to exhibit the lines and bands to the very extremity of the red space.

"The power of heat alone," says our author, "to render a gas which is almost colourless as red as blood, without decomposing it, is in itself a most singular result, and my surprise was greatly increased when I afterwards succeeded in rendering the same pale nitrous acid gas so absolutely black by heat, that not a ray of the brightest summer's sun was capable of penetrating it. In making this experiment the tubes frequently exploded, but by using a mask of mica and thick gloves, and placing the tubes in cylinders of tinned iron, with narrow slits to admit the light, there is little danger of any serious accident."

It is a remarkable fact that the liquified gas in the very same tube, produces none of the fixed lines, and exercises no other action on the spectrum than any ordinary fluid of the same orange colour.

As the points of maximum absorption in coloured bodies were distinctly coincident with some of the principal lines in the solar spectrum, our author suspected that the same might be true with regard to the nitrous gas lines, and he therefore formed the solar and the gaseous spectrum with light passing through the same aperture, so that the lines in the one stood opposite to those in the other, and their coincidence became a matter of simple observation. He then superimposed the two spectra, when both were formed by solar light, and thus exhibited at once the two series of lines and bands, with all their coincidences and deviations. This phenomenon is one of the most splendid in physical optics.

"The general coincidence," continues our author, "thus cognizable by the eye, requires to be more particularly explained. Though some of the larger lines in the gaseous spectrum coincide with some of the larger ones in the solar spectrum, yet, in many cases, faint and narrow lines in the one coincided with strong and broad lines in the other; and there were some strong gaseous lines, and even broad bands, to which I could discover no counterpart in Fraunhofer's map of the spectrum, which at this stage of my inquiry was the standard to which I appealed. This discrepancy at first embarrassed me, and as I observed it in parts of the spectrum where Fraunhofer had drawn every line which he had seen with his finest instruments, I abandoned all hopes of being able to establish the general principle of their identity. I was therefore obliged either to renounce this principle as one contradicted, or rather not confirmed by observation, or to consider Fraunhofer's delineations as in fault, and to enter upon the Herculean task of making a better map of the spectrum.

Prismatic Spectrum.

"After a little practice in the observation of the solar spectrum, I discovered most of the lines which I had in vain sought for in Fraunhofer's map, as the counterpart of those in the gaseous spectrum. I saw well marked groups, of which he had only given one of the lines, and shaded bands, and well defined lines, which his method of observation had not permitted him to discover.

New maps of the solar spectrum.

"After I had laid down all the principal features in the spectrum, I was able to examine the two classes of lines *pari passu*. The action of the gas upon invisible lines in the spectrum rendered them visible by slightly enlarging them, and this enlargement of a solar line indicated the existence of a corresponding line in the gaseous spectrum.

"By this double process, and by methods of observation which I believe have never before been used in optical researches, I have been able to execute three different maps of the spectrum: *first*, a map of the lines in the solar spectrum; *secondly*, a map of the same spectrum, exhibiting at the same time the action of nitrous acid gas upon solar light, previously deprived of a number of its definite rays; and, *thirdly*, a map shewing the action of the gas upon a continuous and uninterrupted spectrum of artificial white light. The general scale of these delineations is *four* times greater than that of Fraunhofer, but some portions of them are drawn on a scale *twelve* times greater, which became necessary from the impossibility of representing in narrower limits the numerous lines and bands which I have discovered. The length of Fraunhofer's spectrum is $15\frac{1}{2}$ inches; mine, upon the same scale, is nearly 17 inches. The length of the general spectrum, which I have delineated, is about *five* feet eight inches, and the length of a spectrum, corresponding to the scale on which I have delineated parts of it, is *seventeen* feet.

"Fraunhofer has laid down in his map 354 lines, but in the delineations which I have executed, the spectrum is divided into more than 2000 visible and easily recognised portions, separated from each other by lines more or less marked, according as we use the simple solar spectrum, or the solar and gaseous spectra combined, or the gaseous spectrum itself, in which any breadth can be given to the dark spaces."

In this minute examination of the spectrum, our author was led to the discovery of a system of lines and bands, particularly in the red and green spaces, which at other times wholly disappeared; but by a diligent comparison of these observations, he found that these *lines and bands depended on the proximity of the sun to the horizon, and were produced by the absorptive action of the earth's atmosphere.* Sir David Brewster is about to publish his map of the lines of the spectrum, as produced by the light of the sun itself, and another map of the spectrum, as modified by the action of the earth's atmosphere. He has, however, made the following general observations on the subject, in reference to the fixed lines of Fraunhofer:—"The atmosphere," he remarks, "acts very powerfully round the line D, and in the space immediately on the least refrangible side of it. It developes a beautiful line in the middle of the double line D, and by enlarging a group of small lines on the red side of D, it creates a band almost as dark as the triple line D itself. It widens generally all the lines, but especially the darkest one, which I call *m*, between C and D. It developes a band on the least refrangible side of *m*, and it acts especially upon several lines, and developes a separate band

[1] A remarkable example of a very definite action on a part of the spectrum was discovered by Sir D. Brewster in the triple oxalate of chromium and potash. It absorbs a very definite band on the least refrangible side of B, a part of the spectrum over which it exercises no general absorptive action. This band lies in the space B*a* of Fraunhofer's map, so that if *x* is its place, B*x* will be $\frac{1}{3}$ B*a*, or its index of refraction in the water spectrum is almost exactly 1·33070·1.—See *Phil. Trans.* 1835, p. 93.

[2] *Phil. Trans.* 1837, part ii. p. 245.—*Edin. Trans.* vol. xii.

Periodical Colours.

on the most refrangible side of C. The lines A, B, and C are greatly widened, and lines and bands are particularly developed between A and B, and generally throughout all the red space.

"Most of the lines thus widened by the atmosphere are faint lines previously existing in the spectrum, and I have no doubt that they would be seen in the spectrum of the lime ball light condensed by a polyzonal lens, and acted upon by thirty miles of atmosphere.

"The absorptive action of the atmosphere shews itself in a less precise manner in the production of dark bands, whose limits are not distinctly defined. A very remarkable narrow one, corresponding to one produced by the nitrous acid gas, is situated on the most refrangible side of C. Another very broad one lies on the most refrangible side of D, close to a sharp and broad band of yellow light, displayed by the general absorption of the corresponding part of the superimposed blue spectrum. There is also an imperfectly defined atmospheric action, corresponding to a group of lines where Dr. Wollaston placed his line C.

"This general description of the atmospheric lines, while it indicates the remarkable fact, that the same absorptive elements which exist in nitrous acid gas, exist also in the atmospheres of the sun and of the earth, leads us to anticipate very interesting results from the examination of the spectra of the planets. Fraunhofer had observed in the spectra of Venus and Mars some of the principal lines of the solar spectrum. This, indeed, is a necessary consequence of their being illuminated by the sun, for no change which the light of that luminary can undergo is capable of replacing the rays which it has lost. But while we must find in the spectra of the planets and their satellites, all the defective lines in the solar spectrum, we may confidently look for others arising from the double transit of the sun's light through the atmospheres which surround them."

PART V. ON PERIODICAL COLOURS.

Periodical colours.

The phenomena of periodical, or recurrent colours, as Dr. Young has very appropriately called them, are among the most interesting in optics, and have been treated of by him with great ability, under our article on CHROMATICS, though not in that popular and descriptive manner, which is required in a work like this. We shall therefore endeavour to give as perspicuous an account as we can of this interesting portion of physical optics.

SECT. I.—*On the Interference of Light.*

Interference of light

The discovery of the interference of light in its simplest form, is due to Grimaldi, as we have already seen. He admitted the sun's light into a dark room, through two small and equal apertures of a circular form. Two cones of diverging light were thus formed, and by receiving them on a screen, held beyond the place where the cones intersected each other, two overlapping luminous circles were seen on the screen. A partially illuminated penumbra surrounded each of these cones, and at the place where the rays from each aperture met, the screen was, generally speaking, more strongly illuminated by the union of the two lights; but the boundaries of the penumbral portions which overlap are much darker than the corresponding portions of the penumbra which do not overlap, as if the one light had at this part put out the other. Upon intercepting the light from one of the apertures, this dark part became brighter, and upon restoring the light it again became darker. The result, therefore, was here unambiguous, and justified the observation of Grimaldi, "that an illuminated surface may be rendered darker by the addition of light."

Dr. Hooke made a similar experiment, and observed the darkness produced at the overlapping part of the two cones; but this result, remarkable as it was, seems to have excited no interest during nearly a century and a half, till Dr. Young, who was unacquainted with the experiment of Grimaldi, obtained the same result in a different manner, and thus laid the foundation of the most interesting department of physical optics. The following is the experiment which he gave as "*An Experimental Demonstration of the Interference of Light.*"[1] "I made a small hole in a window shutter, and covered it with a piece of thick paper, which I perforated with a fine needle. For greater convenience of observation I placed a small looking-glass without the window shutter in such a position as to reflect the sun's light in a direction nearly horizontal upon the opposite wall, and to cause the cone of diverging light to pass over a table on which were several little screens of card paper. I brought into a sunbeam a slip of card about $\frac{1}{30}$th of an inch in breadth, and observed its shadow either on the wall, or on other cards held at different distances. Beside the fringe of colour on each side of the shadow, the shadow itself was divided by similar parallel fringes of smaller dimensions, differing in number according to the distance at which the shadow was observed, but leaving the middle of the shadow always white. Now these fringes were the joint effects of the portions of light passing on each side of the slip of card, and inflected or rather diffracted into the shadow. For a little screen being placed either before the card, or a few inches behind it, so as either to throw the edge of its shadow on the margin of the card, or to receive on its own margin the extremity of the shadow of the card, all the fringes which had before been observed in the shadow on the wall, immediately disappeared, although the light inflected on the other side was allowed to retain its course, and although this light must have undergone any modification that the proximity of the other edge of the slip of card might have been capable of occasioning. . . . Nor was it for want of a sufficient intensity of light that one of the two portions was incapable of producing the fringes alone; for when they were both uninterrupted the lines appeared, even if the intensity was reduced to one-tenth or one-twentieth."

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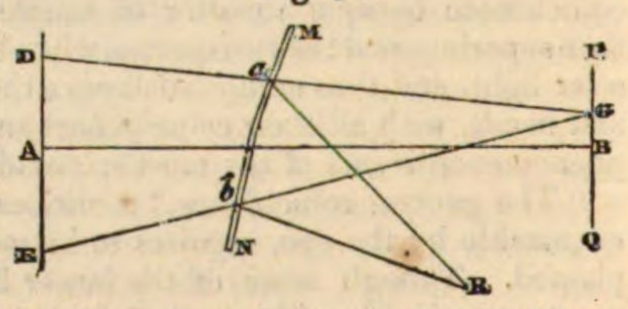
Dr Young's experiment.

Although this experiment is a very decisive one, yet M. Fresnel made one still more instructive and general, and free from any of the objections that might have been urged against that of Dr. Young. He took two plane mirrors M, N, which were inclined at a very great angle, a little less than 180°, and having allowed a beam of light R*a*, R*b*, proceeding from a luminous point R such us the focus of a small lens, he received the reflected rays on a piece of paper PQ. If the light was homogeneous, there was seen upon the paper a succession of bright and dark bands alternating. These bands are parallel to the line of intersection of the two mirrors, and they are placed symmetrically on both sides of a plane passing through the line of intersection of the mirrors, and through a point A bisecting the distance of the points D, E, the virtual points of divergence of the two reflected pencils *a*G, *b*G. That these parallel bands are produced by the mutual interference of the two beams is at once proved by intercepting one of them, by covering one of the mirrors, when the whole series disappears. It is found also by measuring distances of the same bands from the line of intersection of the mirrors, and when the paper PQ, is placed at different distances from the mirrors, that their different

Fresnel's experiment.

Fig. 92.



[1] *Phil. Trans.* 1804; or *Elements of Nat. Phil.* vol. ii. p. 639.

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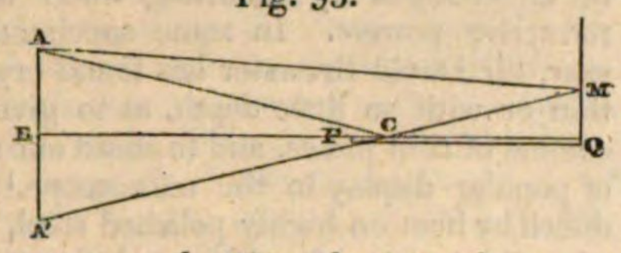
points lie in hyperbolas whose foci are D, E, and common centre A.

Professor Lloyd's experiment.

A still more simple and elegant method of exhibiting the phenomena of interference, has been given by Professor Lloyd of Dublin, which any person may repeat with a single piece of plate glass. Having placed horizontally a piece of black glass QP, with his eye behind it at QM, he viewed by very oblique reflexion, when the angle of incidence was nearly 90°, a horizontal narrow aperture placed at A, a distance of three feet from the reflector QP. The proper degree of obliquity was easily found by bringing the reflected image of the aperture A to coincide very nearly with the direct image, in which case the direction of the reflected plane BPQ, bisected the distance AA′. When the ray AM, which fell directly upon the eye at M, interfered with the reflected rays CM, which reached it by a longer path, they produced a system of fringes or bands, which were distinctly visible when received upon an eye-piece placed at a short distance from the reflector. This system of bands was exactly similar to one-half of the system seen in Fresnel's experiment. With compound white light the first band was a *bright* one and *colourless*. This was followed by a very sharply defined black band; then came a coloured, and so on alternately, seven alternations being easily counted, and the breadth of the bands being, as near as the eye could judge, the same throughout the series, and increasing with the obliquity of the reflected beam. "The first dark band was of *intense blackness*, but the darkness of the succeeding bands were less intense, as they were of higher orders, and after three or four orders they were completely obliterated by the closing in of the bright bands. At the same time the coloration of the bright bands increased with the order of the band, until after six or seven alternations, the colours of different orders became superimposed, and the bands were thus lost in a diffused light of nearly uniform intensity."[1] "These bands," continues Professor Lloyd, "are most perfectly defined when the eye-piece is close to the reflector. Their breadth and coloration increased with the distance of the eye-piece, but remained of a finite and very sensible magnitude, when the latter was brought into actual contact with the edge, a circumstance which distinguished them altogether from the diffracted fringes formed on the boundary of the shadow."

Fig. 93.



When homogeneous light is used, the bands are alternately bright and dark, and varying in magnitude with the refrangibility of the light, as will be afterwards more fully explained. If the light of the sun is used, the bands may be distinctly seen upon a white screen placed at MQ. That they are produced by interference may be easily proved, either by stopping the direct ray AM, or the reflected ones CM, when the whole system of bands disappears.

The leading phenomena of interference may be likewise exhibited by transmitting the light emanating from a luminous point through the two faces of a prism, the inclination of which is about 180°. The pencil or ray passing through one of the faces, will be slightly inclined to the ray passing through the other, at a small angle, and will interfere with it at their point of concourse, and produce the usual fringes. This form of the experiment is described by Sir Isaac Newton, who considered the fringes as produced by inflexion.

In all the preceding experiments two pencils of light issuing from the same point or luminous origin, are made again to meet, the one having arrived at the point of concourse by a different and a longer path. Now it is obvious from the experiments, that when the two portions of light thus intervening reach the spot where they interfere by paths exactly equal, they form a bright fringe, having the intensity of its light greater than that of either portion. It is also evident that other bright fringes are produced, when their paths differ in length; and if we suppose d to be the difference of paths by which the second bright fringe is produced, similar bright fringes will be produced when the differences in the lengths of the paths are $2d$, $3d$, $4d$, $5d$, $6d$, &c. But it is manifest from the preceding experiments, that if the two portions of light interfere at intermediate points, or when the difference in the length of their paths is $\frac{1}{2}d$; $d+\frac{1}{2}d$; $2d+\frac{1}{2}d$; $3d+\frac{1}{2}d$; $4d+\frac{1}{2}d$, &c. the two interfering portions *destroy each other* and produce blackness, as appears from the dark fringes lying between the bright ones. Here, then, we have a remarkable property of light established by direct experiment, and well fitted to guide us in our inquiries into the physical cause of the various phenomena of light. We shall find the same beautiful property shewing itself under various aspects in a succession of interesting phenomena, which we shall now proceed to describe.

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Sect. II.—*On the Colours of Thin Plates.*

Colours of thin plates.

The colours of thin plates were first observed by Mr. Boyle, who remarks that all chemical essential oils, as also good spirits of wine, by shaking till they rise in bubbles, appear of various colours, which immediately vanish when the bubles burst, so that a colourless liquor may be immediately made to exhibit a variety of colours, and lose them in a moment, without any change in its essential principles.

Boyle.

Mr. Boyle also noticed these colours in soap bubbles and in turpentine, and he succeeded in blowing glass sufficiently thin to exhibit them. In 1666 Lord Brereton observed similar colours produced by the thin plates which are formed on the surface of glass by the action of the weather.

Hooke.

In the year 1672 Dr. Hooke exhibited to the Royal Society a soap bubble with all its colours, in fulfilment of a promise which he had made at a previous meeting, "to exhibit something which had neither refraction nor reflexion, and yet was diaphanous." "By means of a glass pipe he blew several small bubbles out of a mixture of soap and water, when it was observable that at first they appeared white and clear, but that after some time the film growing thinner, there appeared upon it all the colours of the rainbow, first a pale yellow, then orange, red, purple, blue, green, with the same series of colours repeated." Dr. Hooke made considerable progress in the investigation of this class of phenomena, and made experiments with thin plates of Muscovy glass, (Mica). He found that a faint yellow plate of this substance laid upon a blue one constituted a very dark purple; and Sir Isaac Newton, in a private letter to Dr. Hooke, a copy of which is now before us,[2] acknowledges that Hooke had observed previous to him, "the dilatation of the coloured rings by the obliquation of the eye, and the apparition of a black spot at the contact of two convex lenses, and at the top of a water bubble."

Newton.

Sir Isaac Newton, whose investigations we shall presently give in his own words, made great progress in discovering the law of the phenomena, and it is a curious fact not to be overlooked by physical inquirers, that his theory of the phenomena, elaborated with the utmost care and generalising an extensive series of facts, is now exploded, while the theoretical views of Dr. Hooke are almost universally admitted.

Mr. Melville of Edinburgh proposed to make a permanent soap bubble by freezing, but we believe the experiment

[1] *Transactions of the Royal Irish Academy*, vol. xvii.

[2] Dated Cambridge, February 5, 1675–6.

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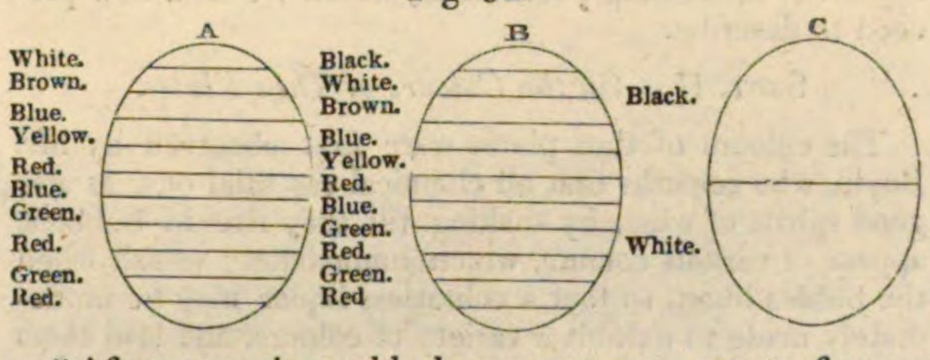
has never yet succeeded. Dr. Joseph Reade has however been more fortunate in making what may be called a permanent soap bubble, for illustrating the colours of thin plates, which we saw him exhibit at the meeting of the Physical Section of the British Association at Liverpool in 1837. The following is his own account of the method of making it: "Having put two ounces of distilled water into an eight-ounce phial, and having added about the size of a large pea of Castile soap, I placed the bottle in a saucepan of boiling water on the fire; the bottle was speedily filled with a dense volume of vapour, which expelled all the air. I now corked it, and after cooling and thus condensing the vapour, had perhaps as perfect a vacuum as could be formed, even by the best air-pump. I now held the bottle laterally between my hands, and by means of a circular and brisk motion formed a circular film, on which by resting the bottle on an inclined plane, were formed after a short time, all the parallel bands or series of colours in the following order: 1. a white or silvery segment at top; 2. a snuff-coloured brown, inclined at bottom to a deep red; 3. blue; 4. yellow; 5. red; 6. blue; 7. green; 8. red; 9. green; 10. red; 11. green. (As in fig. A.)

Dr Reade's permanent soap bubble

Fig. 94.



"After some time a black segment was seen to form at the top of the white, and continually to increase in size. (See fig. B.) After a few minutes the parallel bands increased in breadth, and running into one another, only three or four distinct bands were seen. Nothing can exceed the beauty of these colours, equal to those of the rainbow, or the plumage of the tropics: whilst writing this description, I have these bands in a bottle before me, feasting my eyes on their beauty. In a few minutes more this black segment or aqueous film occupies, perhaps, half the circular film, and the lower half becomes white tinged with orange. (See fig. C.)

"If we now incline the bottle towards the experimenter's breast, the saponaceous atoms producing these colours, are seen to float in the region of the black or aqueous; when placed again on the inclined plane, they fall to the bottom of the film. In some time more the entire film becomes black, and all the colours disappear.

"Having now placed the bottle in a basin of boiling water, the evaporation was increased, and the black film soon became clothed with saponaceous atoms, which being variously condensed, produced all the colours of the clouds when the sun is setting on a summer's evening. On again placing the bottle on the inclined plane, the parallel bands were again formed by the attraction of cohesion, and the colours afterwards gave place to the black film. I held the bottle laterally between my hands, and by means of a circular motion washed it, and thus clothed it with saponaceous atoms, which went through the same process on placing the bottle on the inclined plane. By means of washing the film every morning, I preserved it for more than three weeks."

Colours of thin plates exhibited in nature.

The colours of thin plates are often exhibited in nature in the most beautiful manner. On the surface of little pools of mossy water, and especially in the proximity of springs containing iron, we observe thin bright films generally whitish and often yellow and reddish. Between the plates of a mass of mica, and sulphate of lime, and talc, we observe thousands of open spaces where the rings are sometimes circular, consisting only of the first tint above blackness, viz., the white of the first order, sometimes two, three, or more colours according to their size, while at other times the rings or fringes are extremely numerous and often irregular. These colours are all produced by thin plates of air or of vacuity in these fissile minerals, and the colours may be all changed by admitting water or fluids of different refractive powers. In some specimens of Labrador felspar, Sir David Brewster has found crystallised cavities so thin or with so little depth, as to give the most splendid colours of thin plates, and to afford one of the finest subjects of popular display in the microscope.[1] The colours produced by heat on highly polished steel, are all the colours of a thin plate of oxide; and they are often beautifully displayed on the sides and on the bars of grates.

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When glass is exposed to the action of the weather, its surface acquires a thin film, which at first can only be rendered visible by examining the faint light reflected from it when it is in contact with a fluid of nearly the same refractive power. It forms most rapidly on the panes of glass in stable windows, but it is seen in the highest perfection in the specimens of decomposed glass found among the remains of Roman buildings. The glass is to a certain depth entirely decomposed into thin films of extreme beauty, reflecting the most brilliant colours to the eye, and transmitting tints of the most exquisite brilliancy, and far surpassing any of the colours produced by art.[2] Coloured films of the richest tints are also seen upon both the faces of cleavage of a sort of artificial mother of pearl, which has been called *nacrite*, and described by Mr. Horner in the *Phil. Trans.*[3] These films are all thin plates of extreme tenuity.

When we breathe upon glass at a proper temperature, and examine with a magnifier the margin of the film while evaporating, or when we observe the evaporation of different volatile fluids, we shall perceive many interesting examples of the colour of thin plates.

One of the finest exhibitions of this kind with which we are acquainted, is that which is produced by the ammonio-sulphate of copper, and which was observed by Sir David Brewster. A solution of the ammonio-sulphate of copper in water, is spread upon a clear plate of glass or any other surface. In the course of an hour or two, a similarly coloured film is formed upon its surface, exhibiting the colours of thin plates from the white of the first order upwards. When the solution is strong, or the stratum of fluid deep, the thickness of the film increases, and the colours rise to higher orders, of a beautiful green and pink colour. When the colours are such as we would wish to preserve, an aperture must be made in the film, and by inclining the plate the fluid must be allowed to run out slowly, leaving the film on the surface of the glass. This film will become hard and permanent after the aqueous part of it has been evaporated. The fringes of colour take the shape of the mass of fluid, or of the piece of glass whose surface is covered with it.

One of the most extraordinary examples of the colours of thin plates, or rather of the blackness that immediately precedes these colours, and one which almost requires the evidence of ocular demonstration to credit, is the existence of filaments, or of a down of quartz so exceedingly minute as to be incapable of reflecting light. The very remarkable specimen of quartz in which this was discovered by Sir David Brewster belongs to the cabinet of the Duchess of Gordon. The original crystal was $2\frac{1}{4}$ inches in diameter, and of a light smoky colour, but impervious to light except in small pieces. Mr. Sanderson, lapidary in Edinburgh, had broken up the crystal for the purposes of his profession, but the apparent foulness of the fracture induced him to lay it aside. The following is an account given by Sir David Brewster, of the principal fracture.

[1] *Edin. Trans.* vol. xi. p. 322. [2] *Phil. Trans.* 1837, part ii. [3] Id. Id. 1836, p. 49, and 1837, part ii.

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"At first sight, the absolute blackness of the separated surfaces seemed to me as it did to every one, to be owing to a thin film of opaque and minutely divided matter that had insinuated itself into a fissure of the crystal; but this opinion was immediately overturned when I observed that both surfaces were equally and uniformly black, and that they were also perfectly transparent by transmitted light.

"Although I had now no doubt that the phenomenon was entirely of an optical nature, and that the blackness of the surfaces arose from their being composed of short and slender filaments of quartz, whose diameter was so exceedingly small that they were incapable of reflecting a single ray of the strongest light, yet it became desirable to establish this curious fact by experimental evidence.

"Having found that no detergent substances either removed or diminished the superficial blackness, I subjected the fragment to the action of cold and hot acids; but the surface continued unaltered by these operations. I now immersed the fragment in oil of anise seed, which approaches to quartz in its refractive power, and upon examining the light reflected at the separating surfaces of the oil and the quartz, I found that the blackness disappeared, and that the fragment, whether seen by reflected or transmitted light, comported itself like any other piece of quartz of the same translucency. Upon removing the oil from the surfaces, it resumed its original blackness, and the filamentous or velvety nature of the surface was rendered evident to the eye by the slight change of tint which was produced by pressing the filaments to one side.

"As the preceding experiments are sufficient to prove that the size of the minute filaments was less than the thickness of a thin plate of quartz which lost the power of reflecting light, it became interesting to obtain an approximate measure of their magnitude. The thinnest substance ever observed, is the aqueous films of the soap bubble previous to its bursting. Newton, however, remarked that the films still reflected a faint image of the candle or of the sun. Hence its thickness must have corresponded nearly with what Newton calls the *beginning of black*, which appears in water at a thickness of the 750,000th part of an inch. The tint, however, of the quartz surface is of a much deeper character, and cannot exceed the *very black* of Newton's scale which corresponds in *quartz* to *one-third of the one-millionth part of an inch*, or to *one-fourth* of the thinnest part of the soap bubble.

"If the two surfaces of quartz had separated by filaments of a larger size, the colour of the filamentous surface might have been *red*, or *blue*, or *yellow*, or *green*; but though such a structure would have been more dazzling to the eye, it yet would have been less wonderful than the one which has now been described."

The colours of thin plates may also be exhibited by pressing together two glass prisms that have moderate refracting angles. Various coloured fringes or portions of coloured rings will be seen by viewing the light reflected from the surfaces in contact, and in a much fainter degree, by examining the transmitted light. The same phenomena may be seen with unusual brilliancy, by taking a thick piece of glass, and having made a scratch on one side of it with a file, apply a heated wire to the scratch, so as to produce a crack in the glass, which may be extended at pleasure by a second and third application of the hot wire. If we now examine the surface of this crack in different directions, we shall see it covered with coloured fringes, which may be made to vary in breadth and position, by opening or closing the crack with the force of the hand.

When we wish to examine and measure the coloured rings with care, the method used first by Hooke, and subsequently by Newton, should be adopted. Two convex lenses of very long focal length are placed the one above the other, so as to touch at their vertex; or a plano-convex lens may have its plane side AB laid upon the convex side CD, fig. 97, of another lens. Sir Isaac Newton used for the uppermost lens a plano-convex one, whose focal length was fourteen feet, and for the lowermost a double convex lens, whose focal length was fifty feet. These lenses must then be held together, and pressed if necessary by three clamp screws, as shewn in fig. 95. The following is the general account of the phenomenon given by Sir Isaac Newton, though somewhat abridged:—

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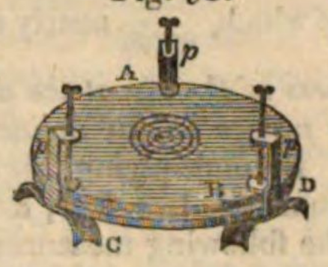
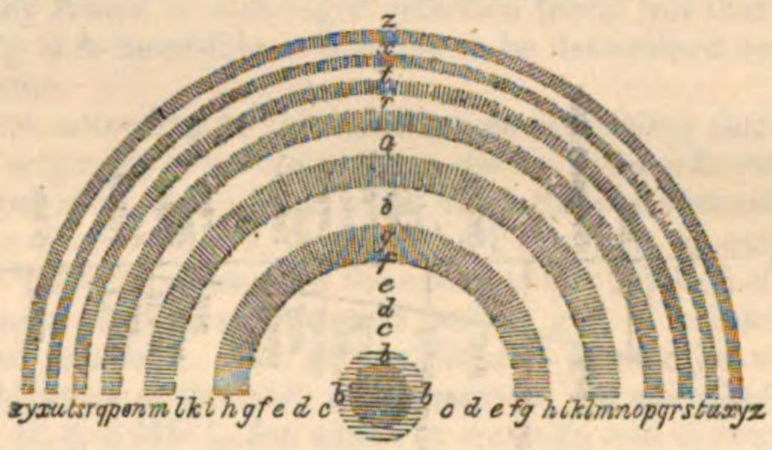
Fig. 95.



"Next to the pellucid central spot made by the contact of the glasses, succeeded *blue*, *white*, *yellow*, and *red*. The blue was so little in quantity, that I could not distinguish any violet in it, but the *yellow* and *red* were as copious as the *white*, though four or five times more than the *blue*. The next order of colours round those in the *second*, was *violet*, *blue*, *green*, *yellow*, and *red*, all of them copious and vivid except the green. The *third* order was *purple*, *blue*, *green*, *yellow*, and *red*, the green being more vivid than in the last order. The *fourth* order was only *green* and *red*, the green being copious and lively, being bluish on one side, and yellowish on the other. The red was very imperfect: the succeeding rings or orders of colours were very faint; and after three or four orders, they ended in perfect whiteness. The form of the whole system of rings, when the lenses were most compressed, so as to produce the black spot in the centre, as shewn in fig. 96, where *a*, *b*, *c*, *d*, *e*; *f*, *g*, *h*, *i*, *k*;

Fig. 96.



l, *m*, *n*, *o*, *p*; *q*, *r*; *s*, *t*; *v*, *x*; *y*, *z*, indicate the different colours beginning at the centre, viz. 1. *black*, *blue*, *white*, *yellow*, *red*; 2. *violet*, *blue*, *green*, *yellow*, *red*; 3. *purple*, *blue*, *green*, *yellow*, *red*; 4. *green*, *red*; 5. *greenish blue*, *red*; 6. *greenish blue*, *pale red*; 7. *greenish blue*, *reddish white*.

In order to find the interval between the glasses, or the thickness of the plate of included air (or space) at which each colour was produced, Sir Isaac measured the diameter of the first six rings at their brightest part, and found their squares to be in the arithmetical progression of the odd numbers 1, 3, 5, 7, 9, &c., and the intervals between the glasses are obviously in the same progression, one of the surfaces being plane, and the other spherical. He then measured the diameter of the rings at their darkest points, and found their squares to be in the arithmetical progression of the even numbers, 2, 4, 6, 8, 10, &c.

In order to find the absolute thickness of the plate of air or space at which these different rings were produced, he measured the diameter of the fifth ring at its darkest point as produced by the different object-glasses.

Diameter of Sphericity of the object-glass.	Diameter of fifth dark ring.
182 inches	$\frac{100}{1774784}$
184 inches	$\frac{5}{88850}$

and dividing these diameters by 5, we obtain the diameter

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of the first ring he obtained, $\frac{1}{88739}$ and $\frac{1}{88850}$; but as these measurements were taken at an angle of incidence of 4°, the results must be diminished in the ratio of the seccant of 4°, or 10029, so that we have $\frac{1}{88952}$ and $\frac{1}{89063}$, the mean of which, $\frac{1}{8900}$ nearly expresses in parts of an inch, *the thickness of the air at the darkest part of the first dark ring at a perpendicular incidence.*

By multiplying this interval by the series of odd and even numbers, 1, 3, 5, 7, &c., and 2, 4, 6, and 8, &c., we obtain the following measures of all the rings :—

	Thickness of the air at the brightest part.	Thickness of the air at the darkest part.
First Ring,	$\frac{1}{178000}$	$\frac{2}{178000}$ or $\frac{1}{89000}$
Second Ring,	$\frac{3}{178000}$	$\frac{4}{17800}$ $\frac{2}{89000}$
Third Ring,	$\frac{5}{178000}$	$\frac{6}{17800}$ $\frac{3}{89000}$
Fourth Ring,	$\frac{7}{17800}$	$\frac{8}{17800}$ $\frac{4}{89000}$

Effects of oblique incidence.

After measuring the diameters of the rings at different angles of incidence, Sir Isaac obtained the following results:

Angle of Incidence on the Air.		Angle of Refraction into the Air.		Diameter of the Ring.	Thickness of the Air.
Degr.	Min.				
00	00	00	00	10	10
06	26	10	00	$10\frac{1}{13}$	$10\frac{2}{13}$
12	45	20	00	$10\frac{1}{3}$	$10\frac{2}{3}$
18	49	30	00	$10\frac{3}{4}$	$11\frac{1}{2}$
24	30	40	00	$11\frac{2}{3}$	13
29	37	50	00	$12\frac{1}{2}$	$15\frac{1}{2}$
33	58	60	00	14	20
35	47	65	00	$15\frac{1}{4}$	$23\frac{1}{4}$
37	19	70	00	$16\frac{2}{3}$	$28\frac{1}{4}$
38	33	75	00	$19\frac{1}{4}$	37
39	27	80	00	$22\frac{6}{9}$	$52\frac{1}{4}$
40	00	85	00	29	$84\frac{1}{13}$
40	11	90	00	35	$122\frac{1}{2}$

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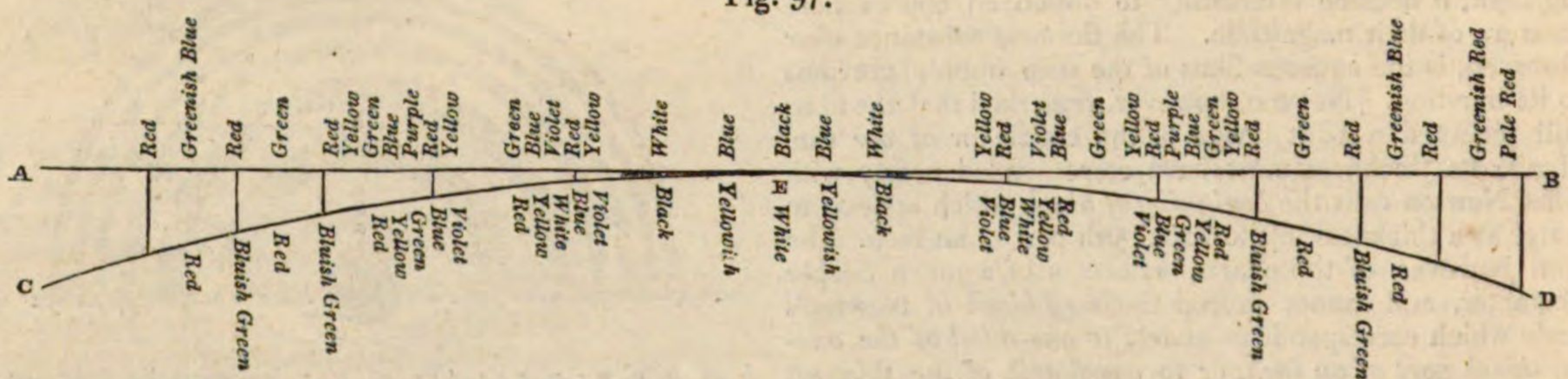
From the results given in the preceding table, Sir Isaac Newton has deduced the following rule :—"That the thickness of the air is proportional to the secant of an angle, whose sine is a certain mean proportional between the sines of incidence and refraction; and that mean proportional, so far as, by these measures, I can determine it, is the first of an 106 arithmetical mean proportionals between these sines counted from the higher sine, that is, from the sine of refraction when the refraction is made out of the glass into the plate of air, or from the sine of incidence when the refraction is made out of the plate of air into the glass."

Fig. 97.



Sir Isaac next proceeds to describe the rings formed by the light transmitted through the two glasses. In this system of transmitted rings, the order of the colours was *yellowish red; black, violet, blue, white, yellow, red; violet, blue, green, yellow, red.* The colours in these rings are very faint at a perpendicular incidence, but become brighter as the incidence increases.

In fig. 97 Sir Isaac has represented the different colours reflected and transmitted, AB and CD being the surfaces of the glasses which touch at E, and the lines uniting them representing their distances in arithmetical progression. The words above the straight line AB are the colours of the *reflected* rings, and those below the circular arch CD those of the transmitted rings.

When water was introduced between the lenses, the colours became fainter, and the rings less, and Sir Isaac found that the intervals were inversely as the indices of refraction in water and air.

The rings were always larger in the homogeneous *red* light of the spectrum than in the *violet* light, in the ratio of $14\frac{1}{2}$ to 9, and he concluded from more detailed observations that the thicknesses of the air between the glasses when the rays were successively formed by the limits of the seven different colours, *red*, *orange*, *yellow*, *green*, *blue*, *indigo*, and *violet*, are to one another as the cube roots of the squares of the eight lengths of a cord which sound the notes in an eighth, *sol*, *la*, *fa*, *sol*, *la*, *mi*, *fa*, *sol*, that is, in the cube roots of the squares of the numbers 1, $\frac{8}{9}$, $\frac{5}{6}$, $\frac{3}{4}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{9}{16}$, $\frac{1}{2}$, or 1; 0·924; 0·885; 0·825; 0·763; 0·711; 0·681; 0·630, that is, if 1 be the interior diameter of any such red ring formed by the extreme red rays, the cube root of $\frac{8}{9}$ will be the interior diameter of a ring at the boundary of the red and orange, and so on.[1]

The colours of thin plates of fluid or solid bodies are not so easily studied as those of air, from the difficulty of procuring, and working with, such evanescent films. Sir Isaac Newton, however, studied them in soap bubbles which, as soon as they were blown, he covered with a clear glass. In this way he observed the colours to emerge like so many concentric rings surrounding the summit of the bubble. As the bubble became thinner, and the subsidence and evaporation of the water, the rings dilated slowly, till they covered the whole bubble, descending in order to the bottom of it, till where they vanished successively. After all the colours were emerged at the top, there grew in the centre of the rings a small round black spot, which continually dilated itself till it became sometimes more than a-half or three quarters of an inch in breadth before the bubble broke. Some light was still reflected from the water at this spot, and Sir Isaac saw within it several smaller round spots much blacker and

[1] It has been noticed by M. Le Blanc, that if the two extreme terms of the preceding numbers, or any other two equidistant from th extremes be multiplied together, their product will always be equal to $\frac{1}{2}$

Periodical Colours.

darker than the rest, but still capable, like the larger one, of reflecting faintly an image of the sun.

By observing how much the colours at the same places of the bubble, or at divers places of equal thicknesses, were varied by the several obliquities of the rings, Sir Isaac obtained the following thicknesses of the water requisite to exhibit one and the same colour at several obliquities :—

Incidence on the water.	Refraction into the water.	Thickness of the water.
0°	0° 0′	10
15	11 11	10¼
30	22 1	10⅔
45	32 2	11⅓
60	40 30	13
75	46 25	14½
90	48 35	15⅕

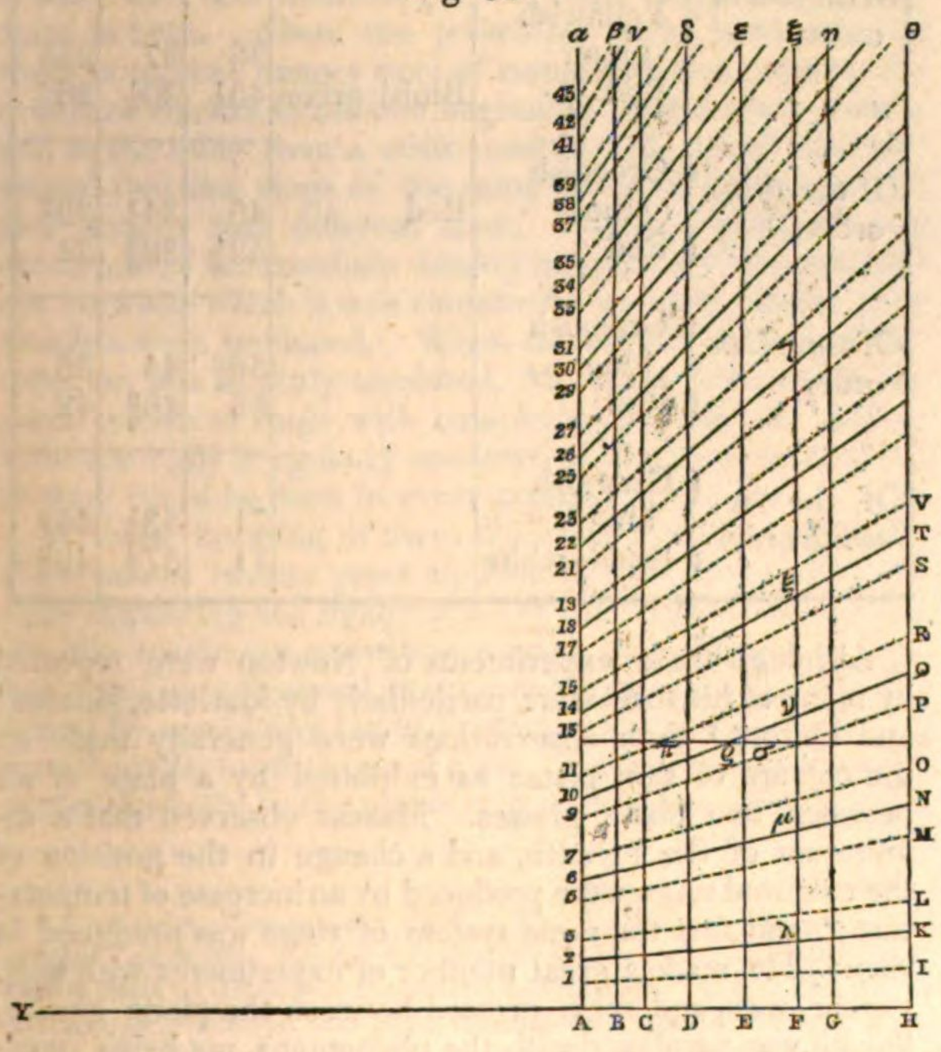
These results harmonise entirely with the rule already given for thin plates of air.

When the system of rings seen by reflection was examined by a prism, and perhaps only eight rings visible, Sir Isaac counted sometimes more than forty on the side of the system to which the refraction was made, though he reckoned by estimation more than a hundred. Soap bubbles also, before they exhibited any colours to the naked eye, have appeared through a prism girded about with many parallel and horizontal rings, to produce which effect it was necessary to hold the prism parallel, or very nearly parallel to the horizon, and to dispose it so that the rings might be refracted upwards.

Composition of the colours of thin plates.

Sir Isaac then proceeds to a very important part of the subject, namely, to explain the composition of the colours of thin plates, a topic of great interest and extensive application : "Let there be taken," says he, "on any right line from the point Y, fig. 98, the lengths YA, YB, YC, YD,

Fig. 98.



&c. in the proportion of the numbers, 6300, 6814, 7114, 8255, 8855, 9243, 1000 ; and at the points A, B, C, D, E, F, G, &c. let perpendiculars Aα, Bβ, Cγ, &c. be erected by whose intervals the extent of the several colours set underneath against them is to be represented. Then divide the line Aα in such proportions as the Nos. 1, 2, 3, 5, 7, 9, &c. set at the points of division denote, and through these divisions from Y draw lines 1 L, 2 K, 3 L, 5 M, 6 N.

Periodical Colours.

Now, if A2 be supposed to represent the thickness of any thin transparent body, of which the internal violet is most copiously reflected on the first ring, then HK will represent its thickness, at which the outermost red is most copiously reflected in the same series. Also A 6 and HN will denote the thicknesses at which those extreme colours are most copiously reflected in the second series, and A 10 and HQ the thicknesses at which they are most copiously reflected in the third series, and so on. And the thickness at which any of the intermediate colours are reflected most copiously, will be defined by the distance of the line AH from the intermediate parts of the lines 2 K, 6 N, 10 Q, &c. against which the names of those colours are written below.

But, farther, to define the latitude of these colours in each ring or series, let A 1 be the least thickness and A 3 the greatest thickness, at which the extreme violet in the first series is reflected, and let HI, and HL, be the like limits for the extreme red, and let the intermediate colours be limited by the intermediate parts of the lines 1 I, 3 L, against which the names of those colours are written, and so on. But yet with this caution, that the reflections be supposed strongest at the intermediate spaces, 2 K, 6 N, 10 Q, &c. and from thence to decrease gradually towards these limits, 1 I, 3 L, 5 M, 7 O, &c. on either side ; where you must not conceive them to be precisely limited, but to decay indefinitely. And whereas I have assigned the same latitude to every series ; I did it, because although the colours in the first series seem to be a little broader than the rest, by reason of a stronger reflexion there, yet that inequality is so insensible as scarcely to be determined by observation.

Now, according to this description, conceiving that the rays, originally of several colours, are by turns reflected at the spaces 1 I L 3, 5 M O 7, 9 P R 11, &c. and transmitted at the spaces AHI 1, 3 LM 5, 7 OP 9, &c. it is easy to know what colour must in the open air be exhibited at any thickness of a transparent thin body. For, if a ruler be applied parallel to AH, at that distance from it by which the thickness of the body is represented, the alternate spaces 1 IL 3, 5 MO 7, &c. which it crosseth, will denote the reflected original colours, of which the colour exhibited in the open air is compounded. Thus, if the constitution of the green in the third series of colours be desired, apply the ruler as you see at $\pi \rho \sigma \phi$, and by its passing through some of the blue at π, and yellow at σ, as well as through the green at ρ, you may conclude that the green exhibited at that thickness of the body is principally consituted of original green, but not without a mixture of some blue and yellow.

By this means you may know how the colours from the centre of the outward rings ought to succeed in order as they were described. For, if you move the ruler gradually from AH through all distances, having passed over the first space which denotes little or no reflexion to be made by the thinnest substances, it will first arrive at 1 the violet, and then very quickly at the blue and green, which, together with that violet compound blue, and then at the yellow and red, by whose farther addition that blue is converted into whiteness, which whiteness continues during the transit of the edge of the ruler from I to 3, and after that by the successive deficiency of its component colours, turns first to compound yellow, and then to red, and last of all the red ceaseth at L. Then begin the colours of the second series, which succeed in order during the transit of the edge of the ruler from 5 to O, and are more lively than before, because more expanded and severed. And for the same reason, instead of the former white there intercedes between the blue and yellow a mixture of orange, yellow, green, blue, and indigo, all which together ought

Periodical Colours.

to exhibit a dilute and imperfect green. So the colours of the third series all succeed in order; first, the violet, which a little interferes with the red of the second order, and is thereby inclined to a reddish purple; then the blue and green, which are less mixed with other colours, and consequently more lively than before, especially the green: Then follows the yellow, some of which towards the green is distinct and good, but that part of it towards the succeeding red, as also that red, is mixed with the violet and blue of the fourth series, whereby various degrees of red, very much inclining to purple, are compounded. This violet and blue, which should succeed this red, being mixed with, and hidden in it, there succeeds a green. And this at first is much inclined to blue, but soon becomes a good green, the only unmixed and lively colour in this fourth series. For as it verges towards the yellow, it begins to interfere with the colours of the fifth series, by whose mixture the succeeding yellow and red are very much diluted and made dirty, especially the yellow, which, being the weaker colour, is scarce able to shew itself. After this the several series interfere more and more, and their colours become more and more intermixed, till, after three or four more revolutions, (in which the red and blue predominate by turns) all sorts of colours are in all places pretty equally blended, and compound an even whiteness.

And since the rays endued with one colour are transmitted, where those of another colour are reflected, the reason of the colours made by the transmitted light is from hence evident.

If not only the order and species of these colours, but also the precise thickness of the plate, or thin body at which they are exhibited, be desired in parts of an inch, that may be also obtained by the assistance of the preceding observations. For according to these observations, the thickness of the thinned air, which between two glasses exhibited the most luminous parts of the first six rings were $\frac{1}{178000}$, $\frac{3}{178000}$, $\frac{5}{178000}$, $\frac{7}{178000}$, $\frac{9}{178000}$, $\frac{11}{178000}$ parts of an inch. Suppose the light reflected most copiously at these thicknesses be the bright citrine yellow, or confine of yellow and orange, and these thicknesses will be F λ, F μ, F ξ, F o, F τ. And this being known, it is easy to determine what thickness of air is represented by G ϕ, or by any other distance of the ruler from AH.

But farther, since the thickness of air was to the thickness of water, which between the same glasses exhibited the same colour, as 4 to 3, and the colours of thin bodies are not varied by varying the ambient medium; the thickness of a bubble of water, exhibiting any colour, will be $\frac{3}{4}$ of the thickness of air producing the same colour. And so according to the same observations, the thickness of a plate of glass, whose refraction of the mean refrangible ray, is measured by the proportion of the sines 31 to 20, may be $\frac{20}{31}$ of the thickness of air producing the same colours; and the like of other mediums. I do not affirm that this proportion of 20 to 31 holds in all the rays; for the sines of other sorts of rays have other proportions. But the differences of these proportions are so little that I do not here consider them. On these grounds I have composed the following table, wherein the thickness of air, water, and glass, at which each colour is most intense and specific, is expressed in parts of an inch divided into ten hundred thousand equal parts.

The Thickness of Coloured Plates and Particles of Air, Water, and Glass.

Periodical Colours.

	Reflected Tints.	Transmitted Tints.	Air.	Water.	Glass.
Their colours of the *first* order.	Very black		$\frac{1}{2}$	$\frac{3}{8}$	$\frac{10}{31}$
	Black	White	1	$\frac{3}{4}$	$\frac{20}{31}$
	Beginning of black		2	$1\frac{1}{2}$	$1\frac{2}{7}$
	Blue	Yellowish red	$2\frac{2}{5}$	$1\frac{4}{5}$	$1\frac{11}{20}$
	White	Black	$5\frac{1}{4}$	$3\frac{7}{8}$	$3\frac{2}{3}$
	Yellow	Violet	$7\frac{1}{2}$	$5\frac{1}{3}$	$4\frac{5}{7}$
	Orange		8	6	$5\frac{1}{6}$
	Red	Blue	9	$6\frac{3}{4}$	$5\frac{4}{5}$
Of the *second* order,	Violet	White	$11\frac{1}{6}$	$3\frac{3}{8}$	$7\frac{1}{3}$
	Indigo		$12\frac{5}{6}$	$9\frac{5}{8}$	$8\frac{2}{11}$
	Blue	Yellow	14	$10\frac{1}{2}$	9
	Green	Red	$15\frac{1}{8}$	$11\frac{1}{3}$	$9\frac{5}{7}$
	Yellow	Violet	$16\frac{2}{7}$	$12\frac{1}{5}$	$10\frac{2}{3}$
	Orange		$17\frac{2}{9}$	13	$11\frac{1}{9}$
	Bright red Scarlet	Blue	$18\frac{1}{5}$ $19\frac{2}{3}$	$13\frac{3}{4}$ $14\frac{3}{4}$	$11\frac{5}{6}$ $12\frac{2}{3}$
Of the third order,	Purple	Green	21	$15\frac{3}{4}$	$13\frac{11}{20}$
	Indigo		$22\frac{1}{40}$	$16\frac{4}{7}$	$14\frac{1}{4}$
	Blue	Yellow	$23\frac{2}{5}$	$17\frac{11}{20}$	$15\frac{1}{10}$
	Green	Red	$25\frac{1}{6}$	$18\frac{6}{10}$	$16\frac{1}{4}$
	Yellow		$27\frac{1}{7}$	$30\frac{1}{3}$	$17\frac{1}{2}$
	Red	Bluish green	29	$21\frac{3}{4}$	$18\frac{5}{7}$
	Bluish red		32	24	$20\frac{2}{3}$
Of the *fourth* order,	Bluish green		24	$25\frac{1}{2}$	22
	Green	Red	$35\frac{2}{7}$	$26\frac{1}{2}$	$22\frac{3}{4}$
	Yellowish green		36	27	$23\frac{2}{9}$
	Red	Bluish green	$40\frac{1}{3}$	$30\frac{1}{4}$	26
Of the *fifth* order,	Greenish blue	Red	46	$34\frac{1}{2}$	$29\frac{2}{3}$
	Red		$52\frac{1}{2}$	$39\frac{3}{8}$	34
Of the *sixth* order,	Greenish blue		$58\frac{3}{4}$	44	38
	Red		65	$48\frac{3}{4}$	42
Of the *seventh* order	Greenish blue		71	$53\frac{1}{4}$	$45\frac{4}{5}$
	Ruddy white		71	$57\frac{3}{4}$	$49\frac{2}{3}$

Although these experiments of Newton were repeated by many of his successors, particularly by Mariotte, Mazeas,[1] and Dutour,[2] their observations were generally made on the colours of thin plates as exhibited by a plate of air between two plane glasses. Mazeas observed that a diminution of the breadth, and a change in the position of the coloured rings, were produced by an increase of temperature;[3] and that the same system of rings was produced in vacuo. He made a great number of experiments with suet, vapour, wax, and rosin pressed between the plane glasses, but he was perplexed with the phenomena, not being aware that he was actually making experiments with mixed plates in which the colours follow an entirely different law. M.

[1] *Mem. Acad. Berlin*, 1752, *and Memoires Presentées*, tom. ii. p. 28. [2] *Memoires Presentées*, tom. iv. p. 724.
[3] He made the lenses almost red hot, and by pressing them with a rod of iron, he saw the rings produced as before.

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Dutour and Sir William Herschel observed the reflected and the transmitted tints at the same time, the last series being reflected to the eye by the lower surface of the glass. and M. Dutour observed these reflected ones more distinctly by making the shadow of an opaque body pass over the upper surface. Sir W. Herschel observed additional sets of rings by increasing the number of reflecting faces; and in producing the primary reflected system by a lens pressed against a metallic reflector, he remarks that the transmitted system must in this case be conceived to have been absorbed by the metallic surface.[1]

M. Arago.

In an interesting paper on the colours of thin plates published in the *Mémoires D'Arcueil*,[2] M. Arago has given an account of some important discoveries on this subject. In viewing the reflected rings through a rhomb of Iceland spar, having its principal section parallel or perpendicular to the plane of incidence, he observed, that the intensity of light in one of the images, varied with the angle of incidence, and that this image vanished at an incidence of 35° the maximum polarising angle for glass. He discovered the very same property in the transmitted rings. This eminent philosopher has also shewn, that when the reflected and the transmitted systems of rings are superposed, they completely neutralise each other, forming white light; and hence he concluded, that their colours were complementary, and the intensities of their illumination exactly the same.

M. Arago next examined the system of rings when formed between a lens and a metallic reflector. When he observed them with the rhomb of spar above mentioned, one of the images vanished as formerly at 35° of incidence, the *angle of maximum polarisation of glass;* but *above* and *below* that angle M. Arago observed the most singular phenomena. At incidences *below* 35°, the two images formed by the doubly refracting rhomb differed only in intensity, the colours and the diameters of the rings being exactly the same in both. *Above* the polarising angle, however, the rings in the two images were of complementary colours, the orders of colours in the one beginning from a black centre, and in the other from a white centre. M. Arago also observed that the rings of the same order of colours in the two images had different sizes. When a plate of any substance of intermediate density between the two substances between which it was contained was used, similar phenomena were produced. When the surface of the metallic reflector was slightly tarnished, M. Arago observed a second system of rings with complementary colours, arising from the light irregularly scattered at the metallic surface, as they could be seen in every position of the eye.

Mr. Airy.

Without knowing of these discoveries of M. Arago, Mr. Airy,[3] about twenty years afterwards, published similar results respecting the modification of the rings above and below the maximum polarising angle; and Professor Lloyd has ingeniously observed, that an analogous result "may be obtained by combining (as in Fresnel's experiment, fig. 92,) a metallic reflector with one of glass. The light being polarised perpendicularly to the plane of reflexion, the central band will be white, when the angle of incidence is below the polarising angle of the glass; at the polarising angle, the interference bars will vanish altogether; and beyond that incidence they will reappear with a *dark* centre in place of a white one. This method of observation would seem to be peculiarly adapted to the investigation of the change of phase produced by metallic reflexion at various incidences."[4]

Professor Lloyd.

Periodical Colours.

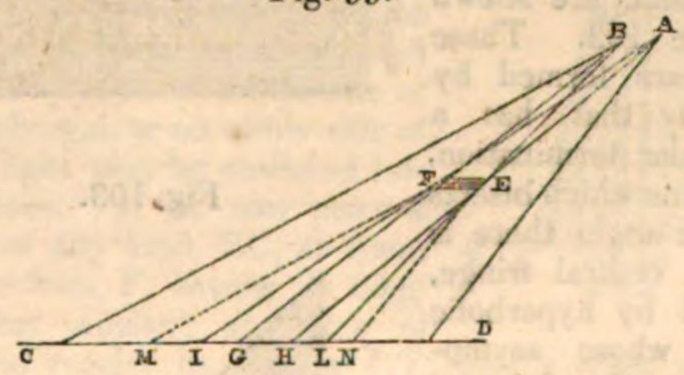
A consideration of Fresnel's expressions, which had led Mr. Airy to make his experiments with a metallic surface, led him also to expect that when the rings were formed between two transparent surfaces of different refractive powers, and when the light was polarised perpendicularly to the plane of incidence, the rings should be *black centred* at incidences below the maximum polarising angle of the least refractive surface, or greater than that of the highest refractive surface, and should be *white*-centred, when the angle of incidence was between these angles. By forming the rings between plate glass and diamond, Mr. Airy found his anticipations correct. In the course of these experiments Mr. Airy observed that the rings did not disappear at the polarising angle of diamond, but that the first black ring contracted as the incidence was gradually increased, and at last took the place of the central white spot. Hence he concluded that there is still some light reflected at the maximum polarising angle of diamond, and that this body has no angle of complete polarisation. See page 376, col. 2.

Sect. III.—*On the Diffraction or Inflexion of Light.*

Diffraction of light.

M. Grimaldi, to whom we owe the discovery of the interference of light, likewise made some important experiments on what is called the diffraction or inflexion of light. Having admitted a ray of solar light into a dark room, through a small hole AB, he placed in the conical beam ABCD an

Fig. 99.



opaque body EF. The shadow of this body was not bounded by the straight lines AEH, BFG, nor by the penumbra IL formed by the lines BEI, AFL, but was enlarged to MN, and was much greater than it should have been, if formed by rays passing in straight lines past the edges of the body. Without the shadow of the body there were three fringes of coloured light, the broadest and most luminous of which, next to the shadow X, fig. 100, was MNO. There was no colour in the middle at M, but it was *blue* at the side NN, and *red* at the other side OO. The second fringe

Fringes without the shadow.

[1] *Phil. Trans.* 1807, 1809, 1810. [2] Tom. iii.

[3] *Cambridge Transactions*, 1832.—The following note upon this paper we confess ourselves unable to understand, "I have carefully verified," says Mr. Airy, "this assertion, (that it is indifferent whether the light is polarised before or after reflexion) because I think that it leads to important theoretical conclusions. If polarisation were a *modification* of light (as Dr. Brewster and others have supposed,) it might be conceived that polarisation before incidence, might destroy its power of producing rings at a certain angle, or might change the tints; but when the reflexion is performed, and the rings are actually visible to the eye with a dark centre, it seems quite inconceivable that any *modification* or *physical change* in the light should make that centre appear white. The satisfactory explanation is, that polarisation is a *resolution* of the vibrations into two sets at right angles to each other, performed in such a manner that the two sets can in general be separately exhibited, and that in this instance only one is transmitted to the eye." The authors criticised in the preceding extract, viz. Malus, Young, Biot, Herschel, and we believe MM. Arago and Fresnel, all considered polarisation as a modification of common light, and if a *modification* certainly a *physical change* without any reference to theory. In every point of view, indeed, the term is philosophical and unexceptionable. If polarisation is a *resolution*, as Mr. Airy affirms, of vibrations *in an infinite number of planes*, into *two sets at right angles to each other*, which we do not question, this is certainly a pretty considerable modification and a very remarkable physical change. As we have nothing to do with theories in describing phenomena we must continue to use the terms which have been regarded as appropriate by our contemporaries.

[4] *Report on Optics*, British Association Reports, *Rep.* 4, 1835, p. 366.

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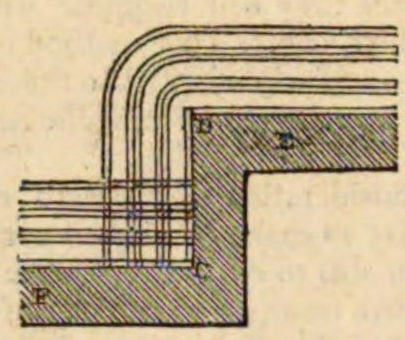
QPR was narrower than MNO. It was colourless in the middle at P, faintly blue at QQ, and faintly red at RR. The third fringe STV resembled the other two, but was the narrowest and the faintest in its colours. They were bent round the edges of the body, as shewn in fig. 101.

Fig. 100.

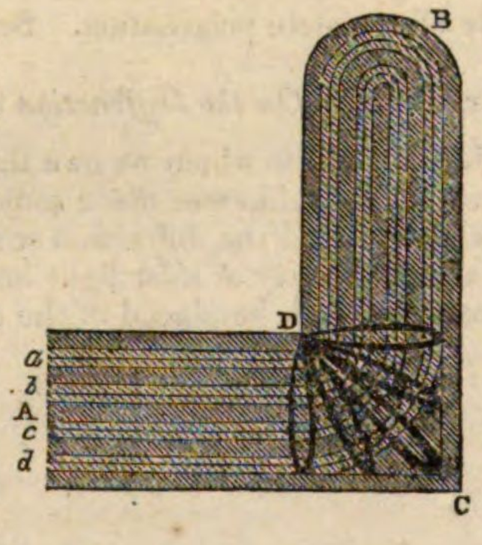
Fig. 101.



Fringes within the shadow.

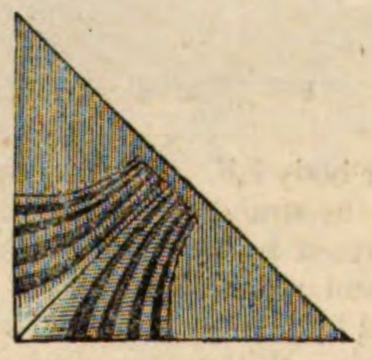
Grimaldi likewise discovered fringes within the shadow, which were best seen when the body was long, the light great, and its distance from the aperture considerable. These internal fringes increased with the breadth of the body, and they became narrower when they increased in number. They were bent round the angles of the body, as shewn in fig. 102, where ADBC is the shadow, and *a*, *b*, *c*, *d* the internal fringes. Short lucid streaks were seen proceeding, as it were, from the angle D, and returning to it, as shewn in the figure.

Fig. 102.



What Dr. Young has called the *crested fringes* of Grimaldi, are shewn in figure 103. These fringes are formed by any body that has a rectangular termination. At the line which bisects the right angle there is a white central fringe, bounded by hyperbolic curves, whose asymptotes are the diagonal line, and on each side of this are two or three other bands, disposed in hyperbolic curves, which are convex to the diagonal, and converging in some degree, as they recede from the angular point.

Fig. 103.



Sir Isaac Newton.

In repeating the experiments of Grimaldi, Sir Isaac Newton admitted the sun's light through a small hole in a piece of lead the forty-second part of an inch in diameter; he found the breadth of the shadow of a human hair, which was the 280th of an inch in diameter, to be as follows:—

Distance of the hair from the aperture.	Distance of the paper receiving the shadow from the hair.	Breadth of the shadow.
12 feet.....	4 inches	0·01666 inches.
12 —	24 —	0·03572 —
12 —	128 —	0·125 —

Upon comparing the breadths of the fringes without the shadow, and their intervals at different distances, he found them to be nearly in the same proportion, the breadths of the fringes being as the numbers 1, $\sqrt{\frac{1}{3}}$, $\sqrt{\frac{1}{5}}$, &c., and their intervals to be in the same progression. Hence the fringes and their intervals together was as the number 1, $\sqrt{\frac{1}{2}}$, $\sqrt{\frac{1}{3}}$, $\sqrt{\frac{1}{4}}$, &c. Periodical Colours.

When the hair was surrounded with water, the very same phenomena were seen, and metals, stones, glass, wood, horn, ice, &c., produced the very same fringes. The following was the order of the colours, reckoning from the shadow:—
First fringe,....Violet, indigo, pale blue, green, yellow, red.
Second fringe,..Blue, yellow, red.
Third fringe,...Pale blue, pale yellow, red.

Fringes in homogeneous light.

When homogeneous light was used, Sir Isaac found that the fringes were *largest* in *red* light, *least* in *violet* light, and of an intermediate size in *green* light. In one case, the distance between the middle of the first fringe on each side of the shadow was $\frac{1}{37{\cdot}5}$ of an inch in *red* light, and $\frac{1}{46}$ in *violet* light.

Knife edges.

From experiments made by Sir Isaac Newton on the light which passed by the edge of a knife, and on that which passed between two knife edges parallel to each other, he concluded that the light of the *first* fringe passed by the edge of the knife at a distance greater than the 100th part of an inch; the light of the *second* at a greater distance than that of the first; and the light of the *third* fringe at a greater distance than that of the second.

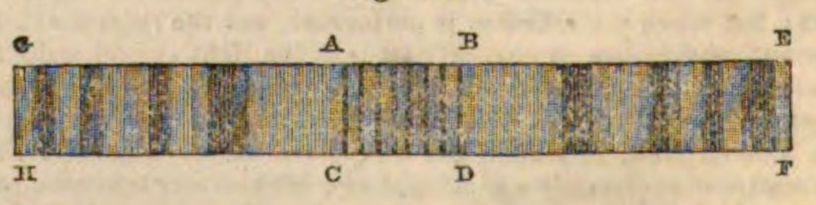
Sir Isaac then stuck into a board the points of two knives with straight edges, so that their edges formed an angle of 1° 47′ 26″, and from the observations which he made on the light which passed between them, he concluded *that the light which forms the fringes is not the same light at all distances of the paper from the knives*, obviously considering each fringe as produced like caustic curves, by the intersection of the inflected rays. When the fringes formed by these inclined knife edges were received on paper held at a great distance, the fringes formed by the one knife edge were bent into the shadow of the other knife, and formed cubical hyperbolas, whose asymptotes were for one set the knife edge which produced the fringes, and a line perpendicular to the line bisecting the angle formed by the knives.

Dr. Thomas Young.

Although many attempts were made during the last century to complete the unfinished labours of Newton on this subject, yet no decided discovery was made till the time of Dr. Thomas Young. This distinguished natural philosopher, in endeavouring to explain the origin of the fringes which surrounded the shadow of the margin of a small circular aperture, conceived that the light nearest its centre was least inflected, and that nearest its edges most; and that another portion of light reflected from the margin of the aperture, and coinciding either exactly or nearly with the direct light, after a circuitous path, would interfere with that light, and produce colour. In November 1803 he confirmed this supposition to a certain extent, in so far as the production of the colours by interference was concerned, by his discovery of the interference of light, as already described.

The fringes formed by inflexion, as observed by Dr. Young, are shewn in fig. 104, where ABCD is the shadow of the inflecting body with its *internal fringes*, which he considered as produced by the light passing on each side of the inflecting body, and bent into the shadow, so as to interfere in the manner already described. This he clearly proved to

Fig. 104.



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be the case; but he was less successful in explaining the external fringes between AC and GH, and between BD and EF. He ascribed them to the interference of rays *reflected from the margin* of the inflecting body, with rays which passed by it directly.

Dr. Young examined the *crested fringes* of Grimaldi in the same manner as he did the internal fringes ABCD. He found that when a screen was placed within a few inches of the inflecting angle of the body, so as to receive only one of the edges of the shadow, all the crested fringes disappeared; but if the rectangular point of the screen was opposed to the point of the shadow, so as barely to receive the angle of the shadow, or its extremity, the fringes were in no way affected.

M. Fresnel

M. Fresnel in France, and M. Fraunhofer at Munich, were simultaneously occupied in studying the inflexion of light, and each of them published the results of their labours, without any knowledge apparently that the other had been similarly occupied. We shall begin by giving an account of Fresnel's experiments.

In place of a small hole, M. Fresnel adopted the ingenious idea of substituting a lens of short focal length, which collected the solar rays into its focus, from which they diverged as from a small luminous aperture. When bodies were placed in this bright light, they gave distinct fringes, the magnitude of which he was able to measure at various distances behind the inflecting body, and at various distances of the inflecting body from the lens, simply by viewing the fringes with an eye-glass furnished with a micrometer, instead of rendering them dull by receiving them upon paper. In this manner he measured their breadths within the one or two-hundredth part of a millimeter. He traced the external fringes up to their very origin, and by the aid of a lens of a short focus, he saw the *third* fringe at the distance of less than the one-hundredth part of a millimeter from the edge of the inflecting body. M. Fresnel made also the important discovery that the phenomena varied with the distance of the inflecting body from the radiating or luminous point, as will be seen from the following measures:—

Distance of the inflecting body from the focus of the lens.	Distance behind the body where the inflexion was measured.	Angular inflexion of the red rays of the first fringe.
0 feet 4 inches.....	.....3.281 feet.....	.....12′ 6″
19 —·48 — ...	.....3·281 —	..... 3 55

from which it appears that the rays experience a less degree of inflexion in proportion to the distance of the inflecting body from the radiant point.

When the inflecting body was kept at a fixed distance from the lens, M. Fresnel measured the inflexion of the same fringe at different distances behind the inflecting body, and the result of these measurements was, *that the successive positions of the same fringe did not lie in a straight line, but formed a curve, whose concavity is turned towards the inflecting body.* The successive positions of the same fringe in all the orders of colours he found to be hyperbolas, having the radiating point and the edge of the inflecting body for their common foci. In some of these curves the maximum deviation from a straight line was the twenty-fifth part of an inch, or nearly fifty times greater than the error of observation.

In explaining the exterior fringes, M. Fresnel agreed with Dr. Young in supposing that rays reflected from the margin of the inflecting body interfered with the direct rays; but he was afterwards led, both by theory and experiment, to renounce this opinion.

He found that the fringes were absolutely independent of the curvature of the margin of the inflecting body, and that in cases where the margin was made extremely narrow or sharp, the small quantity of light which it could reflect would be incapable of producing, by its interference with the direct light, such bright fringes as are actually observed. To assure himself of this, he took two plates of steel, the edge of each of which was rounded in one half of its length, and sharp in the remaining half; he placed the rounded portion of one edge opposite the sharp portion of the other, and *vice versa*. Hence, if the position of the fringes depended on the form of the surface, the effect would thus be doubled, and the fringes appear broken in the middle. They were on the contrary perfectly straight throughout their whole length.[1] M. Fresnel was therefore obliged to suppose, and the supposition he found to be perfectly conformable to the undulatory theory, that rays that pass at a sensible distance deviate from their primitive direction, and interfere with those which pass directly by the edge of the body.

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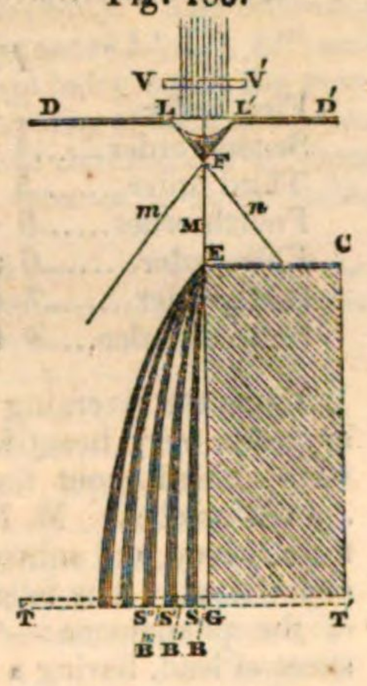
In order to settle this question, M. Fresnel compared the results of Dr. Young's hypothesis with those of his own, and he found that the breadth of any fringe of homogeneous light should be on the two hypotheses as 2 to 1·8726, and having measured the diameter of such a fringe, he found his own hypothesis more consistent with observation than Dr. Young's.

In order to exhibit to the eye the hyperbolic form of the fringes, we have given a representation of them in fig. A, where LL is a lens of short focus, by which the rays of the sun entering a dark chamber, are refracted to a focus F, from which they again diverge, forming the cone F*mn*. Or the lens may be fixed in a large diaphragm DD′, which may stand on the table before the window at which the sun's light enters. By means of a coloured glass VV′ placed on either side of the diaphragm, or on either side of F, the light may be rendered homogeneous. If we now place a screen of any kind, EC, at some distance from F, having its edge somewhat smaller, and free of dust, and receive its shadow GT′ upon a sheet of paper, or any white ground, TT′, or on a glass plate roughened with emery, we shall obtain the section of the fringes formed by diffraction. The line FEG, which is the geometrical shadow, is not the real shadow. On the side of it towards GT′, the paper will not appear *black*, but illuminated with a visible shade, which goes on decreasing nearly uniformly for a considerable distance. On the other side of EG there are several fringes or alternations of light and darkness. The *first* fringe B parallel to the shadow is *bright*, then a band S almost entirely black, which is the *black fringe* of the *first order*, then a second *bright* fringe B′, which is followed by the *second black fringe* S′. These alternations continue to a great distance from G, so that even the sixteenth or seventeenth order may be observed, the bright fringes becoming less coloured, and the black ones more luminous, till they are no longer visible.

Fig. 105.



By varying the distance of the paper TT′ from the screen EC, or of the screen from the focus F, the same fringes are produced with certain variations depending on their distances, the fringes being propagated in hyperbolas, as shewn in the figure. The fringes are *largest* in *red* R, smallest in *violet* V, and of an intermediate size in *green* light G, as re-

[1] *Mémoire sur la Diffraction*, p. 370. Prof. Lloyd's Report, *ut antea*.

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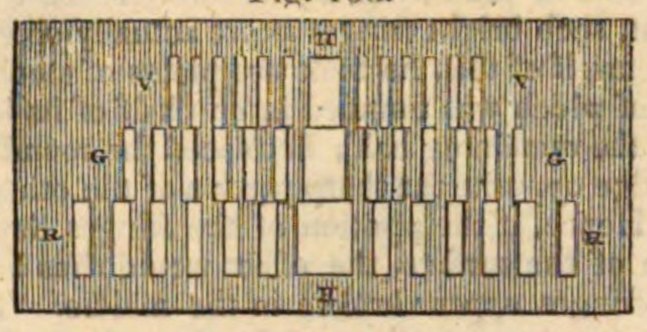
presented in fig. 106, where they are shewn as on each side of the shadow of a human hair HH.

Fig. 106.



The following table shews the angular distances of the seven first fringes from the inflecting body EC, and the geometrical shadow:—

For Red Light.

	Angles, FE = 1000 millimetres.	Angles, FE = 100 millimetres.	Angles, FE = 10 millimetres.
First order	3′ 35″	11′ 20″	35′ 51″
Second order	5 15	16 35	52 25
Third order	6 30	20 32	1° 4 56
Fourth order	7 32	23 50	1 15 21
Fifth order	8 27	26 44	1 24 31
Sixth order	9 17	29 20	1 32 44
Seventh order	10 3	31 45	1 41 21

For Violet Light.

First order	2′ 58″	9′ 22″	29′ 36″
Second order	4 20	13 42	43 18
Third order	5 21	16 55	53 36
Fourth order	6 13	19 40	1° 2 15
Fifth order	6 59	22 5	1 9 48
Sixth order	7 40	24 15	1 16 38
Seventh order	8 18	26 14	1 22 53

Sir John Herschel.

When the diverging light passes through a small circular aperture, very beautiful phenomena are observed, which were studied about the same time by M. Fresnel and Sir John Herschel.[1] M. Fresnel had deduced the phenomena from theory, and subsequently confirmed his deductions by experiment. The following is Sir John Herschel's[2] account of the phenomena:—"Suppose," says he, "we place a sheet of lead, having a small pin-hole pierced through it, in the diverging cone of rays from the image of the sun, formed by a lens of short focus, and in the line joining the centres of the hole and focus prolonged, place a convex lens or eye-glass, behind which the eye is applied. The image of the hole will be seen through the lens as a brilliant spot, encircled by rings of colours of great vividness, which contract and dilate, and undergo a singular and beautiful alternation of tints, as the distance of the hole from the luminous point, on the one hand, or on the eye-glass, on the other, is changed. When the latter distance is considerable, the central spot is white, and the rings follow nearly the order of the colours of thin plates. Thus, when the diameter of the hole was about 1-30th of an inch, its distance (a) from the luminous point about six feet six inches, and its distance (b) from the eye-lens twenty-four inches, the series of colours was observed to be,

"1st order. White, pale yellow, yellow, orange, dull red.

"2d order. Violet, blue (broad and pure), whitish, greenish yellow, fine yellow, orange red, very full and brilliant.

"3d order. Purple, indigo blue, greenish blue, pure brilliant green, yellow green, red.

"4th order. Good green, but rather sombre and bluish, bluish white, red.

"5th order. Dull green, faint bluish white, faint red.

"6th order. Very faint green, very faint red.

"7th order. A trace of green and red.

Periodical Colours.

Sir John Herschel.

"When the eye-lens and hole are brought nearer together, the central white spot contracts into a point and vanishes, and the rings gradually close in upon it in succession, so that the centre assumes in succession the most surprisingly vivid and intense hues. Meanwhile the rings surrounding it undergo great and abrupt changes in their tints. The following were the tints observed in an experiment made some years ago, (July 12, 1819), the distance between the eye-glass and luminous point ($a+b$) remaining constant, and the hole being gradually brought nearer to the former:—

b=	Colour of the central Spot.	Surrounded by
24·00	White.	Rings as in the foregoing description.
18·00	White.	The two first rings confused, the red of the 3d, and green of the 4th orders splendid.
13·50	Yellow.	Interior rings much diluted, the 4th and 5th greens, and 3d, 4th, and 5th reds, the purest colours.
10·00	Very intense orange.	All the rings are now much diluted.
9·25	Deep orange red.	The rings all very dilute.
9·10	Brilliant blood red.	The rings all very dilute.
8·75	Deep crimson red.	The rings all very dilute.
8·36	Deep purple.	The rings all very dilute.
8·00	Very sombre violet.	A broad yellow ring.
7·75	Intense indigo blue.	A pale yellow ring.
7·00	Pure deep blue.	A rich yellow.
6·63	Sky blue.	A ring of orange, from which it is separated by a narrow sombre space.
6·00	Bluish white.	Orange red, then a broad space of pale yellow, after which the other rings are scarcely visible.
5·85	Very pale blue.	A crimson red ring.
5·50	Greenish white.	Purple, beyond which yellow, verging to orange.
5·00	Yellow.	Blue, orange.
4·75	Orange yellow.	Bright blue, orange red, pale yellow, white.
4·50	Scarlet.	Pale yellow, violet, pale yellow, white.
4·00	Red.	White, indigo, dull orange, white.
3·85	Blue.	White, yellow, blue, dull red.
3·50	Dark blue.	Orange, light blue, violet, dull orange.

"The series of tints exhibited by the central spot is evidently, so far as it goes, that of the reflected rings in the colours of thin plates; the surrounding colours are very capricious, and appear subject to no law."

We owe also to Sir John Herschel the following beautiful experiment with two equal apertures placed near each other. The rings are formed about each as in the case of

[1] Sir John Herschel's experiment was made on the 12th July 1819, but was not published till 1825.

[2] *Treatise on Light*, sect. 729, 730.

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one aperture, but these are accompanied with a set of straight parallel fringes, bisecting the interval between their centres, and perpendicular to the line joining their centres. Two other sets of similar fringes appear in the form of a St. Andrew's cross, forming equal angles with the first set, as shewn in Plate CCCLXXXI. fig. 5. When the apertures are unequal, as in fig. 6, these fringes assume the form of hyperbolas, having the aperture in their common focus. By varying the number and shape of the apertures, the phenomena became exceedingly beautiful.

Plate CCCLXXXI. Figs. 5, 6.

M. Poisson

M. Poisson deduced from theory that the centre of the shadow of a small circular opaque disc, exposed to light emanating from a single luminous point, would be precisely as much illuminated by the diffracted light as it would be by the direct light, if the disc were removed. By using a small disc of metal, cemented to a clear and homogeneous plate of glass, M. Arago confirmed this very remarkable result.

M. Arago.

We owe to M. Arago a series of beautiful discoveries respecting the influence of transparent screens in the phenomena of inflexion. When a thick piece of glass was used as a screen on one side of the inflecting body, the rings wholly disappear, as if the screen were opaque. If the screen is very thin, like a film of sulphate of lime or mica, the fringes still remain visible, but shift their places, and are moved from the side where the screen is interposed.

If we make this experiment on the fringes produced by two apertures, we have only to cover one of the apertures with the screen. The same effect, however, will be produced, if we cover both apertures with screens of different thicknesses. In this case the fringes will shift their places from the thicker plate, without suffering any other change.

This beautiful property has been most ingeniously employed by MM. Arago and Fresnel, in measuring the refractive powers of different gases. For as the displacement of the coloured fringes depends on the refractive power, as well as thickness of the plate, its refractive power may be computed from the displacement. In the same manner, if one of the interfering rays are made to pass through tubes filled with different gases, while the other does not, the displacement produced by the gas will give a measure of the refractive power of the gaseous medium.

Fraunhofer

We come now to give some account of the experiments of Joseph Fraunhofer, made with instruments of extreme accuracy, and furnishing data of the highest importance in physical optics.[1]

The apparatus employed by Fraunhofer was a repeating theodolite, whose vernier read off to 4″. In the centre of the circle, but above it, this instrument carries a flat circular plate six inches in diameter, having its axis coincident with that of the theodolite, and graduated separately to 10″. In the middle of this disc is placed a metallic screen, in which the necessary apertures are made, and which is in the axis of the theodolite. The divisions of this disc serve to measure if necessary the angle of incidence of the rays. A telescope, having an object-glass of twenty lines in aperture, and 16·9 inches in focal length, is placed three-and-a-half inches from the centre of this disc. This telescope is placed firmly on the alidade of the divided circle, whose diameter is twelve inches, and the whole is counterpoised. The axis of the telescope is exactly parallel to the horizon, as well as to the plane of this circle. The magnifying power which he employed was from thirty to fifty times. The instrument did not communicate with the floor of the room, from which it was wholly insulated. The heliostate was placed in the prolongation of the optical axis, at a distance of 38 feet $7\frac{1}{2}$ inches from the centre of the theodolite. In order to make the heliostate follow the sun in his hourly motion, the observer could move the screw of the mirror by means of a long rod of iron, which extends from the heliostate to the theodolite, and with this apparatus he could also vary at pleasure the intensity of the solar light. The opening of the heliostate is vertical, being two inches high, and commonly from the 50th to the 100th of an inch.

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By means of an achromatic microscope, magnifying 110 times, Fraunhofer measured the aperture in the metallic screen, which he did to the fifty-thousandth, and sometimes to the hundred-thousandth part of an inch, provided the body was very fine at its edge.

Fraunhofer's first observations were made with a single slit, which was placed before the object-glass of the telescope, which had been previously directed to the aperture in the heliostate, so that the aperture was bisected by the wire of the micrometer. He then saw the fringes shewn in fig. 7, Plate CCCLXXXI. The middle fringe or band $L^{I}L'$ bisected by the micrometrical wire K, was *white*, becoming yellow towards L^{I} and L^{II}, where it was red. In the space L^{I} L^{II} there is a spectrum with very lively colours, viz. *indigo* near L^{I}, then *blue*, *green*, *yellow*, and *red*, near L^{II}. The spectrum in L^{II} L^{III} is much less intense, viz. *blue* near L^{II}, and *yellow*, *green*, and *red* near L^{III}. The spectrum in the space L^{III}, L^{IV}, is still fainter, being *green* on the side L^{III}, and *red* on the side L^{IV}. A great number of spectra follow these, becoming fainter and fainter, and losing themselves in a band of light, which is spread over a great space. All these spectra on both sides of K are perfectly equal, and consequently symmetrical. Both the colours and the spectra shade into one another imperceptibly. The following table contains the average of the distances L^{I}, L^{II}, L^{III}, and L^{IV}, from the central line, all of them being equal, the measures being taken from the red extremity of each spectrum, so that if we wish to have the angle of deviation of L^{II} from KK we have only to multiply the value of L in the table by 2, and so on.

Width of the aperture in parts of a Paris inch.	Breadth of each spectrum or values of KL_1 EL^{II}, &c.	Product of the aperture by the deviation L.
0·11545	—37″·66	0·0000210
0·06098	1—11 ·17	0·0000210
0·03690	1—56 ·6	0·0000209
0·02346	3—4 ·43	0·0000210
0·01237	5—48 ·7	0·0000209
0·01210	6—1 ·84	0·0000212
0·01020	6—57 ·3	0·0000206
0·00671	11—6 ·4	0·0000217
0·00642	11—12 ·2	0·0000209
0.00337	21—10 ·3	0·0000207
0·00308	23—32 ·7	0.0000211
0·00218	33—40	0·0000213
0·00215	35—17	0.0000220
0·00114	1 4—53	0·0000215

From these observations, M. Fraunhofer deduces the following conclusions:

1. *That the angles of deviation of the luminous rays which pass through a single aperture, are in the inverse ratio of the width of that aperture.*

2. *That when a ray is diffracted in passing through a narrow aperture, the distance of similar rays from the middle in the several spectra, form in each case an arithmetical progression, whose difference is equal to the first term.*

3. *That if γ is the aperture, the arches L^{I}, L^{II}, or the deviation of the inflected rays, are in general for the radius of a circle equal to* 1, $L^{I}=\frac{0\cdot0000211}{\gamma}$, $L^{II}=2.\frac{0\cdot0000211}{\gamma}$ $L^{III}=3.\frac{0\cdot0000211}{\gamma}$.

By observing whether the micrometer were appeared or disappeared in the different spectra, Fraunhofer ascertained that the spectra nearest KK, are not composed of homo-

[1] *Neue Modifikation des Lichtes durch gegenseitige Einwirkung und Beugung der Strahlen, und Gesetze derselben.* Von Jos. Fraunhoffa in Munchen. Without a date.

Periodical Colours.

geneous light, but that it becomes more and more homogeneous at greater distances from the axis.

Our author next proceeds to describe the phenomena observed when the two edges which form the narrow aperture, *are at different distances* from the object-glass. When the effective width of the aperture thus formed, is from the 25th to the 50th of an inch, the spectra are the same as those before described; but when the opening becomes less, the spectra on one side of the axis become wider, horizontally than those on the other side. When the apparent aperture was extremely narrow, the spectra on one was two or three times wider than those on the other. By continuing to close the distant edges, the longest spectra begin to disappear successively, so that the fifth spectrum for example, fills almost suddenly the whole field of the telescope, till it ceases to be visible, then the fourth spectrum presents the same phenomena, then the third, and so on. During these changes the spectra on the other side remain unchanged, but when all the former have vanished, *they also disappear in their turn, not successively, but all at once*, which happens when no light passes between the edges. The large spectra are always on the side of the screen, which is nearest the object-glass.

When the apertures, both in the heliostate, and in front of the object-glass, were small circular ones, a system of rings are produced, absolutely the same as those of thin plates, with this difference only, that the centre is *white* in place of *black*. The rays increase in size as the apertures diminish. By varying the apertures he obtained the following results:

1. *That the diameter of the coloured rings are in the inverse ratio of the diameter of the apertures.*

2. *That the distances of the extreme rings (of any given refrangibility) from the centre form an arithmetical progression, whose difference is smaller than the first term.*

3. *That if γ is the diameter of the aperture in Paris inches, we shall have*

$$L=\frac{0{\cdot}0000214}{\gamma}=L^{II}-L^{I}=L^{III}-L^{II}, \text{ \&c.}$$

$$L^{I}=\frac{0{\cdot}0000257}{\gamma}$$

$$L^{II}=\frac{0{\cdot}0000257}{\gamma}+L, \text{ and so on.}$$

Spectra produced by gratings andgrooves

The most important and interesting of Fraunhofer's researches, are those which relate to the spectra produced by gratings, consisting of a number of parallel wires placed parallel also to the narrow linear aperture in the heliostate. He formed these gratings of fine wires stretched across a rectangular frame; the two shorter ends of the frame consisted of two fine screws made with the same die, and having 260 threads in an inch. By placing a wire in each thread he ensured their exact parallelism. The diameter of each wire was 0·002021 of a French inch, and the edge of each wire was distant from the adjacent edge 0·003862 of an inch. The aperture of the heliostate was two inches long, and the 100th of an inch wide, and the frame of wires was placed before the object-glass, so that no other light could be admitted but through them. Fraunhofer was astonished at the phenomena which he saw. He saw the colourless line of light A, Plate CCCLXXXI, fig. 8, in the aperture of the heliostate, exactly as if no wires had been interposed, and at some distance from it on both sides *a great number of coloured spectra exactly similar to those produced by a good prism*. They were larger in proportion to their distance from the central bright line, and they diminished in intensity in the same proportion. A part of these spectra are shewn in figure 8, where A is the aperture of the heliostate, absolutely without colours. On each side of A the spectra are perfectly symmetrical. When the apparatus is well made, the space

Plate CCCLXXXI. Fig. 8.

AH^{I} is absolutely black. The *first* spectrum occupies the space H^{I}, C^{I}; H^{I} being the usual limit of the violet, and C^{I} that of the red. Between H^{II} and C^{II}, there is a second spectrum twice as long as the first; the order of the colours being the same, but their intensity a little less. The third spectrum occupies the space between C^{II} and F^{IV}, but a part of its violet rays are mixed with the red of the *second* spectrum, and also a part of the *red* rays of the *third* with the *blue* rays of the *fourth* spectrum. The *fourth* spectrum is seen between F^{IV} and D^{IV}, its *blue* extremity losing itself in the *third*, and its *red* extremity in the *fifth* spectrum. Many other spectra succeed these, and when the apparatus is good, *thirteen* may be easily reckoned on each side of A.

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But what is the most interesting fact, when the apparatus is good, and the adjustments correct,—the *fixed dark lines in the prismatic* spectrum are seen at C^{I}, D^{I}, these lines being the same as those similarly marked in Plate CCCLXXXI, fig. 1. It is remarkable, however, that A is not seen, a fact which M. Fraunhofer neither notices nor explains. The lines both great and small, are absolutely the same, both in this and the prismatic spectrum, though their distances are widely different.

In a grating in which γ, the distance between the wires is 0·000628, and δ, or the diameter of the wires 0·001324, the following are the distances:

	Diffracted Spectrum.	Water Spectrum.
Distance between the lines B^{I} and C^{I}	2′ 2″·6	1′ 3″·3
..... C^{I} — D^{I}	4 23 2	2 41
..... D^{I} — E^{I}	4 5 ·2	3 16
..... E^{I} — F^{I}	2 39 ·9	2 47
..... F^{I} — G^{I}	3 37 ·6	5 57
..... G^{I} — H^{I}	2 12 ·5	4 14
Total length from B^{I} to H^{I} .	19 1 0	19 1 ·3

The diffracted spectrum is therefore a very extraordinary one. The green space from E to F, is almost exactly the same in both, but all the less refrangible spaces are greatly expanded in the diffracted spectrum, and the more refrangible spaces greatly contracted, the *red* space CD in the diffracted spectrum being *twice as great* as in the water spectrum; and the *violet* space in the water spectrum twice as small.

M. Fraunhofer repeated the above experiments with *ten* different gratings, in which the breadth of the wires and the spaces between them were varied, and he deduces from them the following laws:

1. *For two different gratings in which the parallel wires are of the same size and placed at equal distances, the magnitude of the spectra which arise from the reciprocal influence of a great number of rays diffracted by narrow apertures, and their distances from the axis are in the inverse ratio of the intervals $\gamma+\delta$, that is the space from the middle of one of the openings to the middle of the other.*

2. *In all the perfect mean spectra, or those in which the fixed lines are seen, the distances between the coloured rays of the same nature in the different spectra, or between the same fixed lines in them, form an arithmetical progression, whose distance is equal to the first term.*

3. *In gratings in which the diameter δ of the wires and the distance γ between them is expressed in Paris inches, the first term of the progression for the fixed lines* B, C, D, E, *or those rays which have the corresponding degrees of refrangibility is represented by the following numbers.*

$$B=\frac{0.00002541}{\gamma+\delta};\ C=\frac{0.00002425}{\gamma+\delta};\ D=\frac{0.00002175}{\gamma+\delta};$$

$$F=\frac{0.00001943}{\gamma+\delta};\ F=\frac{0.00001789}{\gamma+\delta};\ G=\frac{0.00001585}{\gamma+\delta};$$

$$H=\frac{0.00001451}{\gamma+\delta}.$$

Periodical Colours.

If we represent the numerator of each of these expressions by a, the angle of deviation of one of the same coloured rays in the *first* spectrum by ϑ', in the *second* by ϑ'', in the *third* by ϑ''', we have generally

$$\vartheta' = \frac{\omega}{\gamma+\delta}, \quad \vartheta'' = \frac{\omega}{\gamma+\delta}, \text{ \&c.}$$

If ν stands for the number of the spectrum, ν being $=0$ for the axis, $=1$ for the first spectrum, 2 for the second spectrum, and if we put $E=\gamma+\delta$ we shall have in general,

$$\vartheta(\nu) = \frac{\nu\alpha}{\varepsilon}.$$

The preceding results having been obtained with angles so small that the arcs and their sines and tangents are nearly in the same proportion, M. Fraunhofer began a new series of experiments with the view of obtaining spectra, in which the angles should be larger and by which he might determine whether it was the arcs or their sines or tangents which had the proportions assigned by the experiments.

This inquiry rendered it necessary to obtain much finer gratings than those he had used. He therefore coated a plate of glass with two or three folds of gold leaf in order to have the interstices filled up, and by a peculiar arrangement he traced upon the glass parallel lines in which ε was $=0.00114$ of an inch. When the lines were drawn closer, no gold remained upon the glass. With this system the spectra were larger, and the fixed lines distinctly seen, but they did not answer his purpose. He therefore thought of spun glass which answered as well as wires; and having covered a plate of glass with a thin coat of fat, so thin that it could scarcely be seen, he traced parallel lines upon it, the intervals of which were only half the size of those on the gold leaf. The spectra produced by this system of lines gave the fixed lines very distinctly, so that their distances from the axis could be accurately measured; but he could not succeed in tracing either upon a layer of fat or black varnish lines closer than this. He at last succeeded in his object of tracing a finer system of lines by using a diamond, with which, by the aid of a machine, he traced lines so fine upon the surface of glass, that they could not be seen by the most powerful compound microscope. In this way he obtained a set of several thousand lines in which $\varepsilon=0.0001223$ of an inch, and which are at distances so very equal, that the fixed lines in the first and second spectrum are clearly seen.[1]

With the system when $\varepsilon=0.0001223$, and the number of lines 3601, the fixed line D is seen double in the first spectrum.

When the light fell vertically on this grating, Fraunhofer obtained the following measures:

Names of fixed lines.	Distance of fixed lines from the axis A. Fig. 8, Plate 1.	Distance of lines in first spectrum.
C^{I}	11° 25′ 20″	C^{I} from D^{I}
C^{II}	23 19 42	1° 10′ 49″
D^{V}	10 14 31	D^{I} from E^{I}
D^{II}	20 49 44	1 5 31
E^{I}	9 9 0	E^{I} from F^{I}
E^{II}	18 32 34	0 32 54
F^{I}	8 26 6	F^{I} from G^{I}
F^{II}	17 3 34	0 58 47
G^{I}	7 27 19	G^{I} from H^{I}
G^{II}	15 3 9	0 34 43
H^{I}	6 52 36	

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With this grating, the *third*, *fourth*, and following spectra were well seen, but the fixed lines could not be seen with sufficient distinctness for accurate measurement in those beyond the *first* and *second*.

He therefore used another grating in which $\varepsilon=0.005919$ of an inch; and when the light fell upon it vertically, he obtained the following results for the first five spectra, with the lines D, E, and F, for the first four, with E, for the first three with F and G, and the first two for H.

Names of fixed lines.	Distance of fixed lines from axis.	Names of fixed lines.	Distance of fixed lines from axis.
C^{I}	2° 20 57	E^{V}	9 28 3
D^{I}	2 6 30	F^{I}	1 44 19
D^{II}	4 13 7	F^{II}	3 28 45
D^{III}	6 20 7	F^{III}	5 13 23
D^{IV}	8 27 43	F^{IV}	6 58 18
D^{V}	10 35 53	G^{I}	1 32 22
E^{I}	1 53 7	G^{II}	3 4 57
E^{II}	3 46 17	G^{III}	4 37 30
E^{III}	5 39 50	H^{I}	1 27 0
E^{IV}	7 33 41	H^{II}	2 50 11

all the observations made with both the systems of lines are represented by the expression

$$\operatorname{Sin} \vartheta^{(\nu)} = \frac{\nu\omega}{\text{—}}.$$

That is with rays falling vertically, the sines of the angle of deviation of any fixed line or ray of definite refrangibility from the axis in the different spectra which succeed others, are as the numbers 1, 2, 3, 4, 5.

The last of these systems of lines has the remarkable property of having all the spectra on one side of the axis twice as luminous as those on the other. Fraunhofer supposed that one of the sides of each line had been sharper than the other, and confirmed this opinion by tracing lines on a layer of fat, so that one line was less sharp than the other, and it produced the same inequality in the intensity of the light of the spectra on each side of the axis.

If the ray does not fall vertically upon the system of grooves or lines, but is inclined to it in a plane which intersects the parallel lines vertically, the same effect is produced as if the distance between the middle of the lines or ϵ were diminished in the ratio of the radius to the cosine of the angle of incidence. Hence *the distance of the spectra from the axis increases as the cosine of the angle of incidence.* If σ therefore is the angle of incidence, then we have $\sin \vartheta^{(\nu)} = \frac{\nu a}{\epsilon \cos. \sigma}$. This, however, is only true when the system of lines is coarse and σ not very large. But in fine systems of lines it is otherwise, the spectra on both sides of the axis are no longer symmetrical, and in the system where $\varepsilon=0.0001223$, when σ is $= 55°$ we have the deviation of D′ on one side of the axis is $= 15° 16'$, and on the other side of the same axis 30° 33′.

Hitherto we have treated of spectra formed by the light transmitted through the gratings, or through plates of glass with systems of lines etched upon one of its surfaces. But M. Fraunhofer examined also the spectra produced by *reflexion* from the etched surfaces of the glass plates. For this purpose, he coated the surface of the glass with a black resinous varnish of the same refractive power as the glass. Then when light reflected from the system

[1] M. Fraunhofer remarks that it requires much good fortune even with $\varepsilon=0.0001223$ to find a diamond point which shall trace *several thousands* of such lines without being altered, and he had succeeded only in obtaining one system. It is only by trial that an useful diamond point can be obtained. As every line requires to be drawn singly with great care, the labour of drawing two thousand is enormous. Fraunhofer has drawn lines so close that there are 32,000 of them in a Paris inch. By etching the first and last line of the system somewhat stronger than the rest, our author, by a microscopic apparatus, measured the distance between these two lines, the etching machine itself reading the lines which are etched. In this way knowing the number of lines, viz. 3601, and the distance between the first and last, he obtained ε or the distance between the middle of any two lines.

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of lines fell on the object-glass of the telescope, the very same phenomena appeared as when the light passed through the same system of lines at the same angle of inclination, spectra not symmetrical being seen. The intensity of the spectra was still such that the distances of the various lines can be determined with great accuracy.

M. Fraunhofer has noticed it as very remarkable that under a certain angle of incidence a *portion of a spectrum* produced by reflexion, consists of entirely polarised light. This angle of incidence varies greatly for the different spectra, and even still very perceptibly for the different colours of one and the same spectrum. Thus with the glass system of lines where $\epsilon=0.0001223$, the ray E^{I} in the green part of the first spectrum is polarised when $\sigma=49°$, but the same green part of the *second* spectrum on the same side of the axis is only polarised when $\sigma=40°$, and the green part of the first spectrum lying on the opposite side of the axis, is not polarised till $\sigma=69°$. In this last case the remaining colours of the spectrum are imperfectly polarised. This was less the case in the second spectrum above mentioned where the colour still remained polarised when the angle of incidence was perceptibly altered. In the spectrum where the green light was polarised at 69°, the light was at no angle of incidence so completely polarised as in the first spectrum at 49°. With a system of lines in which ϵ is larger than the one above mentioned, the green rays in the spectra already referred to, are polarised at totally different angles of incidence.

A very singular consequence arises from the formula deduced from theory by M. Fraunhofer, and representing his experiments. If the distance ϵ between the lines is less than the length of an undulation, and the light falls vertically on the grating, so that $\sigma=o$, it follows that *no coloured ray remains visible*, however the light may fall, and only the *white* light becomes visible in the axis. Hence all scratches or inequalities on polished surfaces can produce no spectra, or no disturbance in the light which the surface refracts or reflects, and consequently no imperfection in the images which they form. M. Fraunhofer likewise draws the conclusion "that it would be impossible by any means to render such inequalities (those less than ω) visible," and that a microscopic object, the diameter of which is $=\omega$, and consists of two parts, cannot be recognised as consisting of two parts. "This," he adds, "shews us the limits which are set to vision through microscopes." This result, if clearly established, would be a very remarkable one.

It is very obvious, that if the distances of the etched lines or the wires in gratings are unequal, the *larger* distances ϵ will give *smaller* spectra, and the *smaller* distances ϵ *larger* spectra, which will be mixed with each other. Fraunhofer, however, conceived it would be interesting to know what would happen if the intervals ϵ were *regularly unequal*, that is, if the unequality in the distances were regularly repeated in equal parts. With this view he etched parallel lines in various ways, regularly unequal upon plates of glass covered with gold leaf. If the distances between the lines are expressed by ϵ', ϵ'', ϵ''' and if one of the equal parts, which consists of unequal ϵ's is expressed by $\epsilon'+\epsilon''+\epsilon'''---+\epsilon^n$ then the distances of the various spectra were found by experiment to be

$$\text{Sin. } \vartheta=\frac{(\nu)\ \nu\omega}{\epsilon'+\epsilon+\epsilon^n---+\epsilon^n}$$

The phenomena of spectra thus produced are chiefly remarkable on account of their different intensity. With some systems of lines of this kind, *several spectra or parts of hem may be wholly wanting*, or have so slight an intensity that they are not easily observed, whilst the succeeding ones again become very intense. Owing to this cause, the fixed lines in these spectra may be observed. In the usual systems consisting of equal spaces ϵ, the lines C^{XII}, F^{XII} or the fixed lines C, F, in the twelfth spectrum can be seen; but with a regularly unequal system of lines, where every division consists of three shades ϵ different among themselves, and are as 25 : 33 : 42, the lines C^{XII}, D^{XII}, E^{XII}, and F^{XII} are seen with such distinctness that their distances from the axis can be accurately measured. The reason of this is, that with such systems of lines, the tenth and the eleventh spectra are almost wholly wanting. With this system of lines, indeed, Fraunhofer saw E^{XXIV} or the line E in the 24th spectrum so distinctly that its distance could be measured.

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M. Fraunhofer, by means of concentric circular lines etched upon glass at equal distances, and by making the aperture in the heliostate circular, has produced circular spectra with circular fixed lines. Their distances from the axis are in the same proportion as in the spectra produced by parallel lines.

When the gratings and systems of lines are immersed in fluids, the same phenomena are produced, but the distances of all the spectra from the axis are diminished in the inverse ratio of the indices of refraction.

Fraunhofer has given also some fine drawings of a beautiful class of phenomena produced by the diffraction of light passing through round and quadrangular apertures either singly or arranged regularly. When a plate of brass perforated with two equal apertures 0·02227 of an inch in diameter, and 0·03831 distant, is placed in front of the object glass, and the aperture of the heliostate round, the extraordinary appearance shewn in fig. 9, plate CCCLXXXII, was seen. It consisted of 65 elliptical spectra distributed in concentric rings, the outermost of which contains 28 spectra, the next 20, the next 12, and the central one five. When the circular apertures are arranged so as to correspond with the four angles of a square, the effect produced is similar to fig. 10.

Plate CCCLXXXII. fig. 9.

Fig. 10.

One of the most splendid figures of this kind is produced by crossing two gratings with the wires at right angles to each other, a circular image is covered with narrow spectra radiating from the centre, but occupying only parts of different radii. The spectra are rectangular of about a line wide, and from five lines to five inches long. The violet end of each is towards the centre. In some places the spectra touch and overlap each other, but the greater number are insulated.

Our limits will not permit us to pursue this most curious subject any farther, and we must refer our readers to Fraunhofer's own work,[1] and to another recently published by Schwerd of Spires in 1835,[2] in which he has given drawings of an immense variety of beautiful phenomena, all of which are capable of being explained by the undulatory theory.

As the various phenomena of diffraction observed by Arago, Fresnel, Young, Fraunhofer, and Schwerd, are susceptible of being explained by the undulatory theory, even facts of the same class, and having a similar origin, cannot possess much interest in our inquiries into the physical causes to which they must be ultimately referred.

Recent discoveries.

We shall now proceed, however, to give an account of a new series of facts discovered by Sir David Brewster, of which the undulatory theory is not capable in its present form of giving the least explanation, and we must there-

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1 See *Edin. Journal of Science*, N. S. No. xiii. p. 101, and No xiv. p 251.

2 *Die Beugungs-ersheinungen, aus dem Fundamental-gesetz dem undulations theorie analytische entwickelt und in Bieldern dargestellt*, Von F. M. Schwerd, Manheim, 1835.

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fore consider such facts as peculiarly calculated to throw light on the physical cause of the phenomena.

In all the phenomena of gratings and systems of lines observed by Fraunhofer, the central image of the luminous aperture in the heliostate is white, a result that might have been expected, as that light is reflected from the original surface of the glass, and cannot interfere with any other light. "If the lines," says Fraunhofer, "were so thick that one touched another, and consequently had no space between them, no light could be regularly reflected from the etched surface, and would, as from every other polished surface, be dispersed. Were the intermediate spaces equally wide as the lines, the etched surface could only regularly reflect half as much light as an equal surface of glass that was not etched, therefore the quantity of regularly reflected light from an etched surface of glass, is in proportion to the quantity of light which is reflected from a surface of glass of the same size not etched, or as the width of the spaces between any two neighbouring lines is to the width of these lines."[1]

These conclusions however irresistible they seem to be, are very far from having any foundation. For upon examining a series of several systems of lines or grooves cut on steel for him by the late Sir John Barton, Sir David Brewster observed, that in several of them the central image hitherto described as *white* or colourless, had a distinct colour which was the same in every part of the system. In one of the systems on which there were 1000 lines in an inch, the central image had its tint a *greenish blue* at a perpendicular incidence, which suffered no change by turning round the plate, nor by reflecting the light from different parts of the system. He found the same colours on various other systems of lines, and upon examining them at different angles of incidence, he found that the tints varied with the incidence, being a maximum at a vertical incidence, diminishing as the incidence increased, and disappearing at an angle of 90°. The following were the general results with the grooves on steel :—

Number of grooves in the inch.	Orders and portions of orders of colours from 0° to 90° of incidence.
500	Citron yellow of the first order shading to white.
625	One complete order of colours, together with the reddish yellow of the second order. The colours very faint.
1000	Four complete orders of colours.
1000	One complete order, with blue, green, and yellowish green of the second order.
1250	One complete order, with blue and bluish green of the second order. The colours very faint.
2000	One complete order, together with blue, green, and greenish yellow of the second order.
2500	One complete order, together with the full blue of the second order.
3333	Gamboge yellow of the first order.
5000	One complete order, together with bluish white of the second order.
10,000	One complete order with blue and fainter blue of the second order.

In the third specimen, with 1000 grooves, mentioned in this table, the following were the four orders of colours:—

Colours.	Angles of incidence.
White	90° 0′
Yellow	80 ½
Reddish orange	77 ½
Pink	76 20
Junction of Pink and blue	75 40
Brilliant blue	74° 30′
Whitish	71
Yellow	64 45
Pink	59 45
Junction of pink and blue	58 10
Blue	56
Bluish green	54 30
Yellowish green	53 15
Whitish green	51
Whitish yellow	49
Yellow	47 15
Pinkish yellow	41
Pink red	36
Whitish pink	31
Green	24
Yellow	10
Reddish	0

These colours are obviously analogous to those of the reflected rings in thin plates, though with a white centre, but they *have not the same composition*. By turning the system of lines round in azimuth, the same colours are seen at the same angles of incidence, and they suffer no change either by varying the distance of the luminous aperture, or the distance of the eye of the observer.

Desirous of seeing what effect would be produced, when the original surface of the steel was almost wholly removed, Sir John Barton executed for our author a specimen with 2000 grooves in an inch, in which this was nearly effected. Unfortunately, however, the diamond point which he used broke before he had executed any considerable space, and the experiments, therefore, with so small a portion, were less complete than could have been desired.

The specimen, however, gave four orders of colours, which were developed at greater angles of incidence than in the preceding table. The following were the results :—

Colours.	Angles of incidence.
White	90° 0′
Straw yellow	
Faint red	
Pink	
First limit of pink and blue	80 00
Blue	
Green	
Yellow	
Red	
Pink	
Second limit of pink and blue	69 40
Blue	
Green	
Yellowish green	
Yellow	
Orange	
Scarlet	
Purple	
Third limit of pink and blue	48 0
Blue	
Brilliant green	
Yellowish green	
Yellow	
Reddish	10 0

The property established by the preceding experiment is certainly one of a very remarkable kind. That a pure and highly polished metallic surface, which reflects light perfectly white, should actually decompose it when the surface is reduced to narrow lines, is inconsistent with every doctrine respecting light. Here there are no rays to interfere,

[1] Fraunhofer, *Edin. Journal of Science*, No. xiii. p.109.

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no doubly refracted pencils, and in short, none of the ordinary conditions on which the decomposition of light depends. That the colour does not arise from light that has entered a certain way into the body interfering with that which is regularly reflected, is obvious from the fact, that in two specimens of 2000 grooves in an inch, impressed on *black* wax, the new colours were very distinct, the vertical tint being a greenish yellow of the second order, in one specimen, and a gamboge yellow in the other, in addition to one complete order of colours at greater incidences.

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The following experiments, intended to shew the effect of a variable refracting power in the reflecting surface, are calculated to give us some insight into the nature of this new property of light. In the following table Sir David Brewster has described the changes produced upon the colours, by placing different fluids on the reflecting surface:—

No. of grooves in an inch.	Maximum vertical tint without a fluid.	Maximum tint with three different fluids.
312½	No colour...	1. Water; tinge of yellow. 2. Alcohol; tinge of yellow. 3. Oil of cassia; faint reddish yellow.
500	Citron yellow of first order	1. Water; tinge of red. 2. Alcohol; diluted pink. 3. Oil of cassia; a bluer pink.
625	Reddish yellow of second order	1. Water; faint pink of second order 2. Alcohol; ditto more pink. 3. Oil of cassia; bluish pink of second order.
1,000	Yellowish green of second order	1. Water; pinkish red, second order. 2. Alcohol; brilliant pink, ditto. 3. Oil of cassia; greenish blue, third order.
1,250	Bluish green, faint	1. Water; yellow, second order. 2. Alcohol; yellower. 3. Oil of cassia; yellowish pink.
2,000	Greenish yellow, second order	1. Water; brownish red, second order. 2. Alcohol; pinkish red, ditto. 3. Oil of cassia; greenish blue.
2,500	Blue, second order	1. Water; dilute green. 2. Alcohol; greenish white, second order. 3. Oil of cassia; bright gamboge yellow.
3,333	Gamboge yellow, first order	1. Water; pinkish red, first order. 2. Alcohol; reddish pink. 3. Oil of cassia; bright blue, second order.
5,000	Bluish white, second order	1. Water; pale yellow. 2. Alcohol; yellow, with tinge of orange. 3. Oil of cassia; yellowish pink, second order.
10,000	Fine blue, second order	1. Water; greenish white, second order. 2. Alcohol; yellowish white. 3. Oil of cassia; brilliant gamboge yellow.

Similar results were obtained with grooves impressed upon wax, so that it follows that more orders of colours, and higher tints, at a given incidence, are developed by diminishing the refractive power of the grooved surface. But one of the most interesting results in this table is the part in which the colours are entirely developed by the fluids applied to the surface; and hence if we had transparent fluids of much higher refractive powers, the colours would be produced when the intervals were much larger.

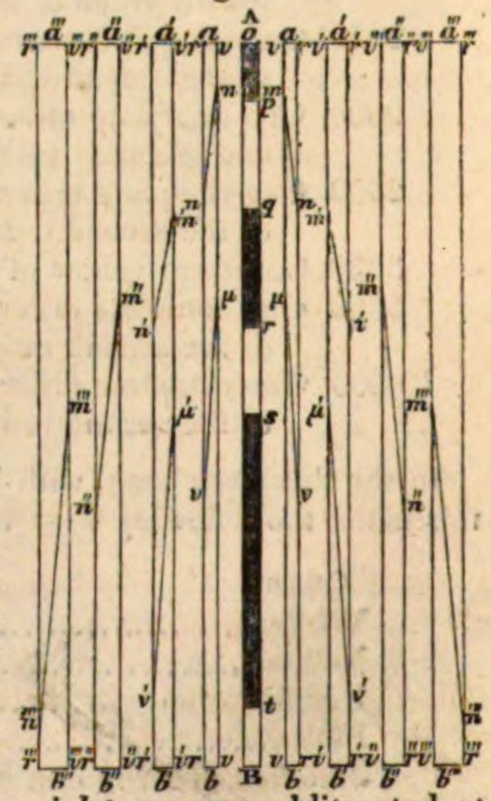
Similar phenomena were developed when the grooves were impressed on the fusible metal, on tin, and on isinglass. In those on isinglass, the new colours were seen also in the transmitted central image, and were extremely brilliant; but they were not decidedly complementary to those in the reflected image. The following were the colours of the reflected and transmitted image in isinglass, beginning from 90° of incidence:—

Colour of the reflected central image.	Colour of the same image, seen by transmission.
Yellow	Deep blue.
Orange	Paler blue.
Pink	Blue.
First limit of pink and blue	Blue.
Blue	Pink.
Green	Orange pink.
Yellow	Orange.
Orange	Yellow.
Pink	Yellow.
Second limit of pink and blue	Yellow.
Blue	Yellow.

Our author was now desirous of observing what took place in the prismatic images, when the colours appeared in the principal or central image.

Let AB, fig. 107, be the reflected image of a long rectangular aperture from the spaces between the grooves, and *ab*, *a′b′*, *a″b″*, *a‴b‴*, the prismatic images of it, *vv*, *v′v′*, &c. being the violet sides, and *rr*, *r′r′*, &c. the red sides of these spectra. Then in the

Fig. 107.



First spectrum *ab*, the *violet* rays are obliterated at *m* at an incidence of 74°, and the *red* rays at *n* at an incidence of 66°, the intermediate colours, blue, green, being obliterated at intermediate points between *m* and *n*, and at angles of incidence intermediate between 74° and 66°. In the

Second spectrum *a′b′*, the *violet* rays are obliterated at *m′* at an incidence of 66° 20′, and the *red* at *n′* at 54° 45′. In the

Third spectrum *a″b″*, the *violet* rays are obliterated at *m″* at 57°, and the *red* at *n″* at 41° 35′. And in the

Fourth spectrum *a‴b‴*, the *violet* rays are obliterated at *m‴* at 48°, and the *red* rays at *n‴* at 23° 30′.

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Another similar succession of obliterated tints takes place on all the prismatic images at a lesser incidence, as shown at $\mu\nu$, $\mu'\nu'$, the *violet* being obliterated at μ, and the *red* at ν, and the intermediate colours at intermediate points. In this second succession the line $\mu\nu$ begins and ends at the same angle of incidence, as the line $m''n''$ in the third prismatic image $a''b'$; and the line $\mu'\nu'$ on the second prismatic image corresponds with $m'''n'''$ on the fourth prismatic image.

Fig. 108.

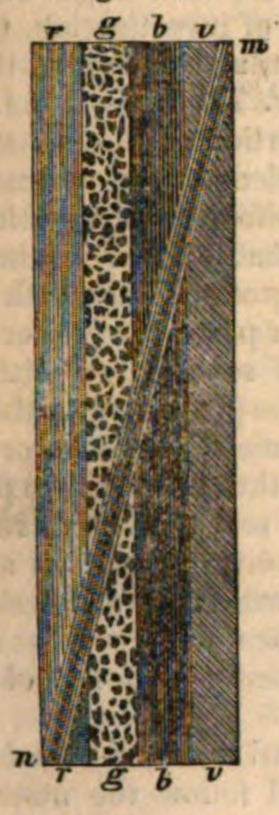
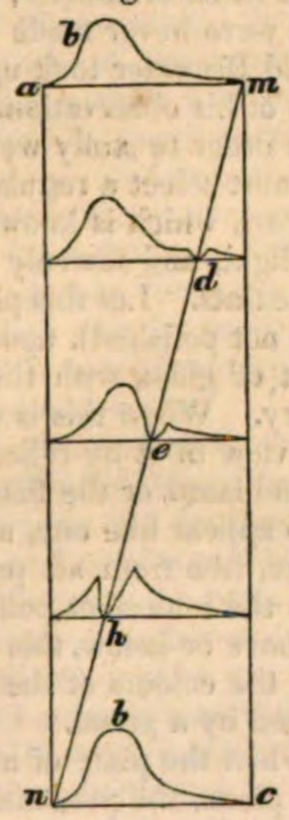


Fig. 109.



This singular obliteration of the colours is shown more clearly in fig. 108, where *rmvn* is a part of one of the prismatic images, *rr* the red space, *gg* the green space, *bb* the blue, and *vv* the violet space. The line of obliteration *mn* begins at *m*, the extreme violet being obliterated there, so that the curve of illumination *abm*, fig. 109, is just affected at one extremity *m*. The line advances into the spectrum, and at the point corresponding to *d*, fig. 109, a portion of the blue and violet is obliterated, as shown by the notch in the curve; at *e* a portion of the green and blue; at *h* a portion of the red and green, and at *n* the extreme red.

A similar obliteration of tints takes place on the ordinary image AB.

The first obliteration, viz. that of the violet, takes place at *o*, fig. 107, and that of the red at *p*; while the intermediate colours disappear at intermediate points. This first space of obliteration has no corresponding one at the same incidence in any of the prismatic images.

The second obliteration of the violet in AB takes place at *q*, and that of the red at *r*, and this corresponds in incidence with the obliterations $m'n'$, $m'n'$ on the second prismatic image.

The third obliteration of the violet takes place at *s*, and that of the red at *t*, and this corresponds in incidence with the four obliterations on the second and fourth prismatic images, viz. $\mu\nu$, $\mu'\nu'$, $m'''n'''$, $m'''n'''$.

In all these phenomena the points m, n, μ, ν, &c. are only the points of minimum intensity, or of maximum obliteration; for the tints never entirely disappear, and those obliterated at each line *mn* form an oblique spectrum containing all the prismatic colours.

The analysis of these curious and apparently complicated phenomena becomes very simple when they are examined under homogeneous illumination. The effect produced in red light is represented in fig. 110, where AB is the image of the rectangular aperture reflected from the faces *n* of the steel, and the four images on each side of it correspond with the prismatic images. All these nine images, however, consist of homogeneous red light, which is obliterated at the fifteen shaded rectangles, which are the minima of the new series of periodical colours which cross both the ordinary and the prismatic images. The centres *p*, *r*, *t*, *n*, *ν*, &c. of these rectangles correspond with the points marked with the same letters in fig. 107; and if we had drawn the same figure for violet light, the centres of the rectangles would have corresponded with *o*, *q*, *s*, *m*, μ, &c. in fig. 107. The rectangles should have been shaded off to represent the phenomena accurately, but the only object of the figure is to shew to the eye the position and relations of the minima of the periods.

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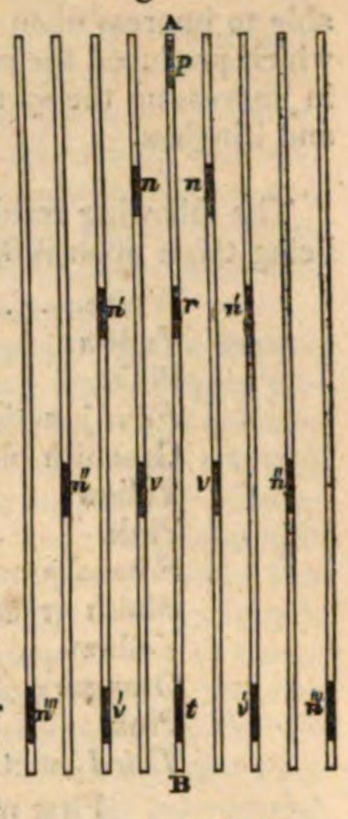
Fig. 110.



If it should be practicable to remove a still greater portion of the faces *n*, the first minimum *p*, fig. 110, would commence at a greater angle of incidence; and other two rows of minima, namely, rows of five and six, would be found extending to the fifth and sixth prismatic images. The arrangement and succession of these is easily deducible from fig. 110, where the law of the phenomenon is obvious to the eye.

The following table contains the angles of incidence reckoned from the perpendicular at which these minima occur in the extreme rays.

Position of the minima in red light.

	Ord.	Im.	1st Prism Im.		2d Prism Im.		3d Prism Im.		4th Prism Im.	
First minima *p*...	76°	0′	66°	0′	55°	45′	41°	35′	23°	30′
Second minima *r*	55	45	41	35	23	30				
Third minima....	23	30								

Position of the minima in violet light.

	Ord.	Im.	1st Prism Im.	2d Prism Im.		3d Prism Im.	4th Prism Im.
First minima	81°	30′	74°	66°	20′	57°	48°
Second minima...	66	20	57	48			
Third minima...	48						

When the steel with 1000 grooves is exposed to common light, and the incident ray is very near the perpendicular, the 5th, 6th, 7th, and 8th prismatic images are combined into a mass of whitish light, terminated externally by a black space. As the angle of incidence increases, the 6th, 7th, 8th, and 9th images are combined into this mass, then the 7th, 8th, 9th, and 10th images, and so on; the black space which terminates this mass receding from the axis or image AB, fig. 107, as the obliquity of the incident ray increases.

Having covered the steel plate with water and oil of cassia in succession, I found the angular distances of the black space to be as follows at the same incidence:—

Air	12° 23′
Water	17 15
Oil of cassia	21 22

the sines of which are inversely as the indices of refraction of the fluids.

Phenomena analogous to those above described take place on the grooved surfaces of gold, silver, and calcareous spar, &c.

In order to study this subject under a more general aspect, I was desirous of examining the phenomena exhibited by grooved surfaces of different refractive powers. It was

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obviously impossible to procure systems of lines upon transparent bodies in which the grooves should have exactly the same distance and magnitude; but I conceived it practicable to impress upon different substances the very grooves which produced the preceding phenomena, and I succeeded in impressing the system of 1000 grooves upon tin, realgar, and isinglass.

The following results were obtained with *tin*, the colours being those upon AB, fig. 107:—

White	90°	0′
Yellow.		
Pink.		
First junction of pink and blue	76	20
Greenish blue.		
Yellow.		
Pink.		
Second junction of pink and blue	57	40
Bluish green.		
Yellow.		
Orange.		
Pink.		
Third junction of pink and blue.		
First minimum of red	76°	
Second	61	

The following results were obtained with *realgar*:—

White	90°	0′
Yellow	80	
Pink	75	30
First junction of pink and blue	73	10
Blue	72	
Bluish green	70	15
Yellow	63	
Bright pink	54	
Second junction of pink and blue	47	
Bluish green	41	
Yellow	36	
Pink	32	
More and more pink.		
First minimum of red	72°	0′
Second	61	15

The following results were obtained with *isinglass*. The colours were generally the same as in the steel:—

The first limit of pink and blue was at	75°	45′
The blue of second order	73	45
The second limit of pink and blue was at	54	30

In these experiments the tin gave nearly the same results as the steel; but in the realgar and the isinglass similar tints were produced at a less angle of incidence than in the steel. The minima of the periods were exhibited very finely on the isinglass, and were produced at smaller angles of incidence.

In a specimen with 1000 grooves upon isinglass, the third pink, or that seen upon steel at 36°, was the highest; but after drying, the pink descended to yellow, and subsequently to green.

If the isinglass is removed from the steel when it is still soft, the edges of the grooves get rounded and lose their sharpness, and only one prismatic image is seen on each side of the ordinary image, as in mother-of-pearl.

The mass of white light is finely seen in the impressions taken upon tin, but never appears upon isinglass.

The prismatic colours seen on mother-of-pearl are exactly of the same kind as the prismatic images of grooved surfaces, with this difference, that a single prismatic image only is seen on each side of the common colourless image. The following account of these colours has been given by Sir David Brewster, who first analysed them, and discovered their communicability to wax, the fusible metals, &c. Periodical Colours.

Properties of mother-of-pearl.

Mother-of-pearl, which constitutes the interior lining of the shell of the pearl oyster, and of various other shells, has been long employed in the arts for the purposes of use and of ornament. Every one must have observed the play of prismatic tints, from which this substance derives much of its value as an ornament; but the nature and origin of these tints were never made the subject of investigation, till Sir David Brewster took up the subject, and published the results of his observations in the *Phil. Trans.* for 1814.

In order to study well the properties of this substance, we must select a regularly formed piece or plate of mother-of-pearl, which is known by the uniformity of its colour in day-light, and scarcely exhibits in that light any of the prismatic tints. Let this plate be now ground flat on both sides, (but not polished), upon a hone or a piece of slate, or upon a bit of glass, with the powder of schistus, or with fine emery. When this is done, hold the plate close to the eye, and view in it by reflexion the flame of a candle, or of an argand lamp, or the flame of two or three candles, so placed as to appear like one, and we shall see a dull and reddish image, free from all prismatic colours, its dulness arising from the imperfect polish of the surface. On one side of, or above or below, this image, will be seen a brighter image with the colours of the spectrum, nearly as if it had been formed by a prism.

When the plate of mother-of-pearl is turned round in its own plane, the prismatic image will follow the motion of the plate, and revolve round the common image, the *blue* rays being nearest the common image, and the *red* rays farthest from it. If the plate is so placed that the prismatic image is in the plane of reflexion, and between the common image and the observer, it will be found that the distance between the two images increases with the angle of incidence, being about 2° 7′ at an incidence not far from the perpendicular, and 9° 14′ at a very great obliquity. This distance between the images varies more rapidly when the plate is turned round 180° in azimuth, so that the common image is between the prismatic image and the observer; but in this case we cannot measure the angle accurately much beyond 60°, when it is nearly 4° 30′.

Beyond the prismatic image, and in the same line with it and the common image, will be observed a mass of coloured light, nearly as far beyond the prismatic image as the prismatic image is from the common image. The distance of this patch of coloured light varies according to a different law from that of the prismatic image, as the rays which form it have previously suffered refraction. This mass of light has a beautiful *crimson* colour at great angles of obliquity. At 37° of incidence it is *green*, and at less angles it has a *yellow* hue, approaching to *white*, and becomes very luminous. These colours become more brilliant when the plate is polished, and have an origin quite different from those of the prismatic image.[1]

Hitherto we have considered the phenomena only when the surface has that degree of polish which accompanies smooth grinding. If a greater degree of polish, however, is communicated to the plate, the common image becomes more brilliant, and *a new prismatic image starts up, diametrically opposite to the first prismatic image, and at the same distance from the common image.* This second prismatic image resembles in every respect the first. Its brilliancy increases with the polish, and when this polish is very high, the second prismatic image is nearly as bright as

[1] See *Phil. Trans.* 1836, p. 55.

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the first, which has its brilliancy a little impaired by polishing. This second image is never accompanied, like the first, by a mass of coloured light. If the polish of the surface is removed by grinding, the second prismatic image vanishes, and the first resumes its primitive brilliancy.

When the preceding experiments are repeated on the opposite surface of the plate of mother-of-pearl, the same phenomena are observed, but in a *reverse* order, the first prismatic image and the mass of coloured light being now seen on the opposite side of the plate.

In examining the light transmitted through the mother-of-pearl, we shall perceive analogous phenomena. A coloured image will be seen on each side of the common image, having the same angular distance from it as those seen by reflexion, and resembling them in every particular; the blue light being nearest the common image, and the red light farthest from it. These two images, however, are generally fainter than those seen by reflexion. When the second prismatic image is extinguished by removing the polish, it is then the most brilliant when seen by transmission; and, in general, the image which is brightest by reflexion is faintest by transmission, and *vice versa*.

In measuring the angular distances of the prismatic image from the common image seen by reflexion, Sir David Brewster had occasion to fix the mother-of-pearl to a goniometer by means of a cement made of rosin and bees' wax. Upon removing it from the cement, by insinuating the edge of a knife, and making it spring off, the plate of mother-of-pearl left a clean impression of its own surface; and he was surprised to observe, that the cement had actually received the property of producing the colours which were exhibited by the mother-of-pearl. This was at first attributed by our author, and others who saw the experiments, to a very thin film of mother-of-pearl detached from the plate, and left upon the cement; but subsequent experiments convinced him that the mother-of-pearl communicated to the cement its own properties.

In order to shew this remarkable property to advantage, the plate of mother-of-pearl should be fixed to a handle like a seal, and its surface carefully cleaned. The sealing-wax should be black, and the impression taken by an impulse of the plate against the black sealing-wax, when rendered as fluid as possible by heat.

The properties of mother-of-pearl may also be communicated in this way to *balsam of tolu*, *gum-arabic*, *gold leaf* placed upon wax, *tinfoil*, the *fusible metal* composed of bismuth and mercury, and to *lead*, by hard pressure, or the blow of a hammer. When the impression is first made upon the *fusible metal*, the play of colours is singularly fine; but the metallic surface soon loses its polish, and the colours gradually decay.

If dissolved *isinglass* or *gum-arabic*, &c., are placed upon the plate of mother-of-pearl, and allowed to harden upon it, they will exhibit in the most splendid manner the colours of the substance; or if we indurate these gums between two plates of mother-of-pearl, we shall have transparent films, exhibiting on both sides the play of the prismatic tints.

In order to show that in these cases no part of the mother-of-pearl is left on the surface, Sir David Brewster plunged a piece of wax, with the impression, into nitric acid, which would instantly have destroyed the carbonate of lime, of which the mother-of-pearl is chiefly composed, but it had no effect on the colorific property of the surface. In soft cements, made of bees' wax and rosin, the slightest degree of heat destroys the superficial configuration, by which the colour is produced. In *sealing-wax*, *isinglass*, *gum-arabic*, and *realgar*, a much greater heat is necessary to destroy it; but in *tinfoil* and *lead*, its destruction can only be effected by the temperature at which they cease to become solid.

If we now examine the prismatic images *reflected* from the wax which has received the impression from an unpolished piece of mother-of-pearl, we shall find that the single prismatic image which is thus produced is on the *right hand* of the common image, whereas it is on the *left hand* of the common image in the mother-of-pearl itself.

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At different angles of incidence, the two coloured images formed by the wax, follow the same laws as those produced by the mother-of-pearl; but the mass of *green* and *crimson* tints never appears in the impressions taken from mother-of-pearl, because they are produced by light which has penetrated the mother-of-pearl, and has after refraction been reflected from one or more thin plates which lie between the strata of which the mother-of-pearl is composed.

In communicating to *isinglass* or *gum-arabic* the superficial structure of mother-of-pearl, their transparency enables us to observe the phenomena of the transmitted colours. The two prismatic images were both visible—the primary one being remarkably brilliant, and the second one scarcely perceptible; but when the light was transmitted through the gum, the primary image was nearly extinct, while the secondary one was unusually brilliant and highly coloured, far surpassing in splendour those which are formed by transmission through the mother-of-pearl itself. When both the surfaces of isinglass or gum-arabic have received the superficial structure of mother-of-pearl, four images are seen. The *transmitted* colours are more brilliant in *gum-arabic* than in *balsam of tolu*, as the latter reflects more light; but the prismatic images have the same degree of colour or dispersion when formed by *isinglass* or *gum-arabic*, as when they are formed upon *metallic* surfaces.

From these facts it is obvious that the principal phenomena of mother-of-pearl have their origin in a particular configuration of its surface. By the use of the microscope Sir David Brewster discovered in every specimen of mother-of-pearl that gave the prismatic images, a grooved structure upon its surface, resembling the delicate texture of the skin at the tip of an infant's finger, or the lines which mark out islands and coasts upon a map.

In many specimens of mother-of-pearl, the grooves are parallel, but they are often arranged in all possible directions like the veins of agate, and in this case the common reflected image is surrounded with a number of prismatic images sometimes arranged in a circular or oval form, more or less regular. Sometimes the spaces between the grooves, or rather the edges of the strata of the shell, can be seen by the naked eye, or by a magnifying power of six or eight times, in which case the prismatic images are less highly coloured, having whitish light in their centre, and are placed close to the common image. At other parts of the same plate, more than 3000 grooves may be counted in an inch, and in some places they cannot be detected by ordinary magnifying powers. When the spaces between the grooves are wide, a new groove often begins, and there is often a sudden change from a series of wide grooves to a series of close ones. When the mother-of-pearl is scratched, the bottom and sides of the scratches are grooved exactly like the parts that are polished.

The direction of the grooves is always at right angles to the line joining the common image and the prismatic image. Had the grooved structure appeared only upon its external surface, the phenomena and the communicable colours would have disappeared when the surface was ground down; but the surprising part of the phenomenon is, that if we grind down the external surface with the finest powders, and polish it to the utmost degree, we never can grind out the grooved structure, and replace it by a flat surface. The edges of the shell break off by the action of the finest powders, so that the termination of one stratum cannot pass into the subjacent stratum without being separated by a distinct line or edge, formed by the fracture of its thin marginal parts. As all the strata have thus a prismatic termination, the mass of green and crimson light is reflect-

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ed from near the edge of the surface upon which the superincumbent stratum lies.

Sir John Herschel discovered in very thin plates of mother-of-pearl a pair of nebulous prismatic images more distant from the central image than the two prismatic ones above described, and also a pair of fainter nebulous images, the line joining which is perpendicular to the line joining the first pair. He saw them by looking through thin pieces between the 70th and 300th of an inch thick. They are produced by a veined structure, in which there were 3700 veins in an inch. They cross the common grooves at all angles, and are parallel to the plane passing through the centres of the two systems of the coloured rings.

The spurious discs of stars first noticed by Sir William Herschel, have been justly considered as arising from diffraction, and have been described as supplementary facts to those discovered by Fraunhofer, in Sir John Herschel's *Treatise on Light;* and we believe every thing distinctly known on the subject, is due to the latter. A good telescope with a small power, shews fixed stars as a bright mass of light with some extraneous rays. A magnifying power of from 200 to 400, in favourable weather, exhibits the star as a well defined disc surrounded by several alternately dark and bright equidistant rings slightly coloured at their margin. These rings are best seen in refracting telescopes, with which the central disc is larger than in reflectors.

In applying apertures of various figures to the mirrors and object-glasses of telescopes, Sir John Herschel obtained the following results:

Effects produced by apertures of various shapes.

With the largest circular diaphragm, either near to, or distant from the spectrum or object-glass, the disc and rings increase inversely as the diameter of the aperture. When the aperture was only one inch in a telescope of seven feet in focal length, the disc of the star was well defined and surrounded with one ring only faintly tinged with *white*, faint *red*, *black*, very faint *blue*, *white*, extremely faint *red*, and *black*, reckoning from the centre. With a half inch aperture, the rings were invisible, the disc greatly enlarged, the light shading off to the circumference like some comets. This is shewn in fig. 11, Plate CCCLXXXII.

Plate CCCLXXXII. Figs. 11.—22.

With annular apertures the phenomena were highly beautiful. When the outside of the annulus was three inches and the inside one and a quarter, *Capella* appeared as in fig. 12, and the double star *Castor* as in fig. 13. When the breadth of the annular aperture is diminished, the disc and the breadth of the rings also diminish, while the number of visible rings increases. The appearance of Capella with annular apertures of 5·5 inches exterior, 5·5 interior, of 0·7 exterior, of 0·2 interior, and of 2·2 exterior, of 2·0 interior, is represented in figs. 14, 15, and 16. In the last figure the disc was reduced to a point, and the rings were so numerous and close that they could scarcely be counted. When the breadth of this annulus was reduced one-half, the rings were invisible.

Fig. 111.

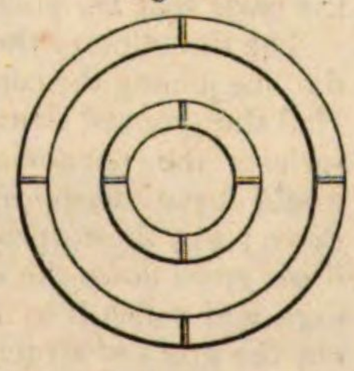

Fig. 17

When two annuli, as shewn in the annexed figure, were used, large halos or rings were seen by Sir John Herschel, as in fig. 17, plate CCCLXXXI.

With an aperture of the shape of an equilateral triangle, or the opening between two concentric equilateral triangles, the figure was that shewn in fig. 18, in which the small central disc was extremely bright, and the field of the telescope black.

When the preceding figure is seen with the telescope out of focus, it changes into fig. 19.

When three circular apertures are placed at the angles of an equilateral triangle, the effect shewn in fig. 20, is produced.

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When three equal and similar annular apertures were arranged in the same manner, the effect was as in fig. 12. When this was thrown out of focus, it had the appearance in fig. 21; when brought better into focus, it changed into fig. 22; and when in focus, into fig. 12.[1]

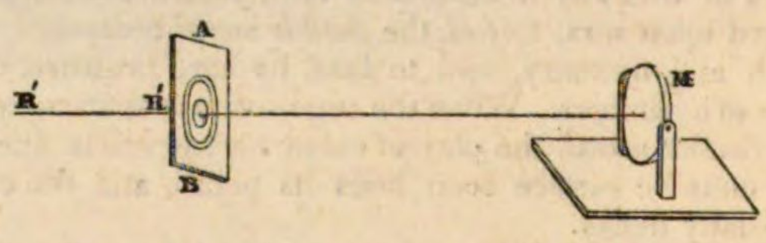
Fig. 20–22.

SECT. IV.—*On the Colours of concave Mirrors or thick Plates.*

Colours of thick plates

The colours produced by thick plates were discovered by Sir Isaac Newton, who has given the following account of them.[1] "There is no glass or speculum however well so ever polished but besides the light which it refracts or reflects regularly, scatters every way irregularly a faint light by means of which the polished surface, when illuminated in a dark room by a beam of the sun's light, may be easily seen in all positions of the eye. There are certain phenomena of this scattered light, which, when I first observed them, seemed very strange and surprising to me. The sun shining into my darkened chamber through a hole in the shutter AB, one-third of an inch wide, I let the intromitted beam of light RR fall perpendicularly upon a glass speculum M, ground concave on one side, and convex on the other, to a sphere of five feet and eleven inches radius, and quick-silvered over on the convex side. And holding a white opake chart, or a quire of paper, at the centre of the sphere to which the speculum was ground, that is, at the distance of about five feet and eleven inches from the speculum, in such a manner that the beam of light might pass through a little hole made in the middle of the chart to the speculum, and thence be reflected back to the same hole: I observed upon the chart four or five concentric irises or rings of colours like rainbows, after the manner that those in the fourth and following observations of the first part of this third book encompassed the black spot, but yet larger and fainter than those. If the distance of the chart from the speculum was much greater or much less than that of six feet, the rings became dilute and vanished,

Fig. 112.



The colours of these rainbows succeeded one another from the centre outwards, in the same form and order with those transmitted through the two object glasses.

Measuring the diameters of these rings upon the chart, I found them also in the same proportion to one another with the rings between the two object glasses. For the diameters of the four first of the bright rings measured between the brightest parts of their orbits at the distance of six feet from the speculum, were $1\frac{11}{16}$, $2\frac{3}{8}$, $2\frac{11}{12}$, $3\frac{3}{8}$ inches, whose squares are in arithmetical progression of the numbers 1, 2, 3, 4. If the white circular spot in the middle be reckoned amongst the rings, and its central light, where it seems to be most luminous, be put equipollent to an infinitely little ring; the squares of the diameter of the rings will be in the progression 0, 1, 2, 3, 4, &c. I measured also the diameters of the dark circles between these luminous ones,

[1] Sir John Herschel's *Treatise on Light*, § 769, &c. in which the reader will find the subject more fully treated.

[2] This account is abridged from Newton's Optics, book ii. part iv. p. 264.

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and found their squares in the progression of the numbers $\frac{1}{2}$, $1\frac{1}{2}$, $3\frac{1}{3}$, &c. The diameters of the first four at the distance of six feet from the speculum, being $1\frac{5}{16}$, $2\frac{1}{16}$, $2\frac{2}{3}$, $4\frac{5}{20}$ inches. If the distance of the chart from the speculum was increased or diminished, the diameters of the circles were increased or diminished proportionally.

"When the beam of the sun's light was reflected back from the speculum, not directly to the hole in the window, but to a place a little distant from it, the common centre of that spot, and of all the rings of colours fell in the middle way between the beam of the incident light, and the beam of the reflected light, and by consequence in the centre of the spherical concavity of the speculum, whenever the chart on which the rings of colours fell was placed at that centre. And as the beam of reflected light, by inclining the speculum, receded more and more from the beam of incident light, and from the common centre of the coloured rings between them these rings grew bigger and bigger, and so also did the white round spot, and new rings of colours emerged successively out of their common centre, and the white spot became a white ring encompassing them; and the incident and reflected beams of light always fell upon the opposite parts of this white ring, illuminating its perimeter like two mock suns in the opposite parts of an iris. * *

"The colours of the new rings were in a contrary order to those of the former, and arose after this manner. The white round spot of light in the middle of the rings continued white to the centre, till the distance of the incident and reflected beams at the chart was about $\frac{7}{8}$ parts of an inch, and then it began to grow dark in the middle. And when that distance was about $1\frac{5}{8}$ of an inch, the white spot was become a ring encompassing a dark second spot which in the middle inclined to violet and indigo. * *

"When the distance between the incident and reflected beams of light became a little bigger, there emerged out of the middle of the dark spot after the indigo a blue, and then out of that blue a pale green, and soon after a yellow and red. * *

"When the distance of the two beams of light at the chart was a little more increased, there emerged out of the middle in order after the red, a purple, a blue, a green, a yellow, and a red inclining much to purple." By the successive development of these colours, rings are formed within the white circle till they become very dilute and vanished while the white ring, and one or two on each side of it, continued visible; and these also vanished when the distance between the two beams of light was still more increased.

"These are the phenomena," says Sir Isaac, "of thick convexo-concave plates of glass, which are everywhere of the same thickness. There are yet other phenomena when these plates are a little thicker on one side than on the other, and others when the plates are more or less concave than convex, or plano-convex, or double convex. For in all these cases the plates make rings of colours, but after various manners."

The Duke de Chaulnes[1] observed colours analogous to those of thin plates, when the surface of a mirror was covered with a thin film of milk after it was dry, or with a screen of gauze or muslin placed at a small distance in front of the mirror. Sir Wm. Herschel[2] has given an account of an interesting experiment in which, by dispersing hair-powder in the air before a metallic speculum on which a beam of light is incident, and receiving the reflected beam on a screen, fine rings of colour are produced; or an analogous phenomena may be seen by scattering hair-powder on the face of a common looking-glass.[3]

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Sir David Brewster has remarked,[4] that the method which he has found the most simple for exhibiting these colours, is to place the eye immediately behind a small flame, from a minute wick fed with oil or wax, so that we can examine them even at a perpendicular incidence. The colours of thick plates may be seen even with a common candle held before the eye at the distance of ten or twelve feet from a common pane of crown glass in a window that has accumulated a little fine dust upon its surface, or that has on its surface a deposition of fine moisture. Under these circumstances they are so very bright, that they may be seen even when the pane of glass is clean.

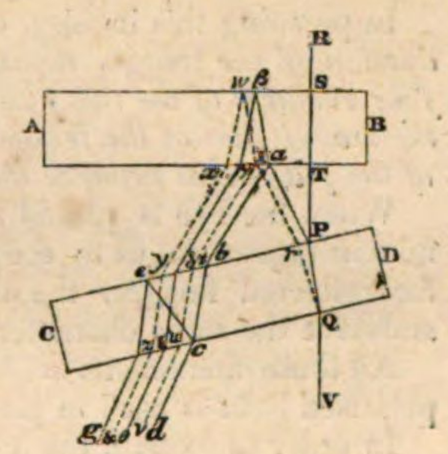
Sect. V.—*On the Colours produced by Double Plates of Glass of equal thickness.*

Colours of double plates of equal thickness.

In 1815, Sir David Brewster published in the Edinburgh Transactions[5] "An account of a new species of coloured fringes produced by the reflection of light between two plates of parallel glass of equal thickness."

In these experiments he cut the plates of glass AB, CD, fig. 112, out of the same piece, and having placed between them a bit of soft bees' wax, he pressed them together till they were at the distance of nearly the tenth of an inch, and slightly inclined to each other as in the figure, till one or more of the reflected images of a circular luminous disc seen in the direction VR by an eye at V, were reflected from the bright and direct image formed by transmitted light. When this was done the reflected image was crossed with about fifteen or sixteen beautiful parallel fringes. The three central fringes consist of blackish and whitish stripes, and the exterior ones of brilliant stripes of red and green light; and the central fringes have the same appearance in relation to the external fringes, as the internal have to the external rings formed by thin plates. If the two plates of glass are turned round in a plane at right angles to the incident ray, the reflected images will move round the bright image, and the parallel fringes will always preserve a direction at right angles to a line joining the centres of the bright and reflected images. Hence it follows, *that the direction of the fringes is always parallel to the common section of the four reflecting surfaces, which exercise an action upon the incident light.*

Fig. 113.



The position of the plates remaining as before, let the inclination of the plates, or, what is the same thing, the distance of the bright and the reflected image, be varied by a gentle motion of one of the plates, *the coloured fringes will be found to increase in breadth as the inclination of the plates is diminished, and to diminish as the inclination of the plates is increased.*

If the light of the circular object, instead of falling perpendicularly upon the plates, is incident at different obliquities, so that the plane of incidence is *at right angles to the common section of the plates*, no fringes are visible across any of the images. But if the plane of incidence is *parallel to the common section of the plates*, the reflected images increase in brightness with the obliquity of incidence, and the coloured fringes become more vivid. When

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[1] *Mém. de l'Acad. de Paris*, 1705, p. 136. [2] *Phil. Trans.* 1807, Part ii. [4] *Treatise on Optics*, Lardner's *Cyclop.* § 77.
[3] See our Article Chromatics, vol. vi. p. 639. sect. ix. [5] Vol. vii. p. 435.

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the angle of incidence increases from 0° to 90°, the images that have suffered the greatest number of reflections are crossed by other fringes, inclined to them at a small angle. At an angle of about 44°, the image formed by four reflexions is covered with interfering fringes; but it is not till the angle of incidence is greater, that this is distinctly seen on the image formed by two reflexions.

Hitherto he had observed no fringes upon the first or bright image, which is composed of light that has not suffered reflexion from the second plate of glass. By concealing, however, the bright light of the first image, so as to perceive the image formed by a *second* reflexion, within the first plate, and by viewing this image through a small aperture, which he found of great service in giving distinctness to all the phenomena, he observed fringes across the first image, far surpassing in precision of outline, and in richness of colouring, every analogous phenomenon which he had seen. When these fringes were concealed, he also observed other fringes on the image immediately behind them, and formed by a *third* reflexion, from the interior of the first plate. He concealed the second image, upon which the fringes were extremely bright, and very faint stripes were seen upon the one immediately behind it.

In examining these phenomena a little more attentively, he observed that the size of the fringes in the first image varied with the distance of the eye from the plates, while those on the second and fourth image diminished with that distance.

In pursuing this inquiry, our author found *that the production of the fringes depends upon the action of all the four surfaces of the two plates of parallel glass; and that the magnitudes of the fringes are inversely as the thickness of the plates that produce them at a given inclination.*

When the eye is placed between the plates and the luminous object, so as to see the *first, third, fifth, seventh*, &c. reflected images, the coloured fringes are also seen, and have the same character as those already described.

All these phenomena are seen without any variation when polarised light is used in place of common light.

In order to explain the changes which the light undergoes in its passage through the plates of glass, let AB, CD, fig. 113, be a section of two plates at right angles to the common section of their surfaces, and let RS be a ray of light incident nearly in a vertical direction. This ray, after passing through the first plate AB, will suffer a small refraction at P and Q, and emerge in the direction QV parallel to RS. At the point P, in the second plate CD, the ray TP will be reflected to *a*, again reflected to *b*, and, after suffering a refraction at *b* and *c*, will emerge in the direction *cd*, forming with RV an angle equal to twice the inclination of the plates. A portion of the reflected ray P*a*, will enter the first plate at *a*, and having suffered reflexion and refraction at *β*, the reflected portion *βγ* will reach the eye at *θ*. The ray P *a b c* will likewise suffer a reflection at *c* and *e*, and will reach the eye at *g*. In like manner, a part of the ray PQ will be reflected at Q, and move in the direction Q*r s t u v*, and another part of it in the direction *s w x y z*, and these rays will suffer several other reflexions; but the images which they form will be so faint, that the eye will not be capable of perceiving them. When the observer, therefore, looks at a luminous body, in the direction SR, through the glass plates, he will perceive two images, one of which is a bright image, seen by the transmitted light QV, and the other is a faint image, seen principally by the reflected light P *a b c d* and composed of several images, formed by the pencils *c d*, *u v*, *ϵ θ*, *z &*, and *e g*. The bright image is not crossed by coloured fringes, but the fringes appear distinctly upon the other image; and the light by which these fringes are formed, has suffered two reflexions from the exterior surfaces, and two refractions at the interior surfaces of the plates."

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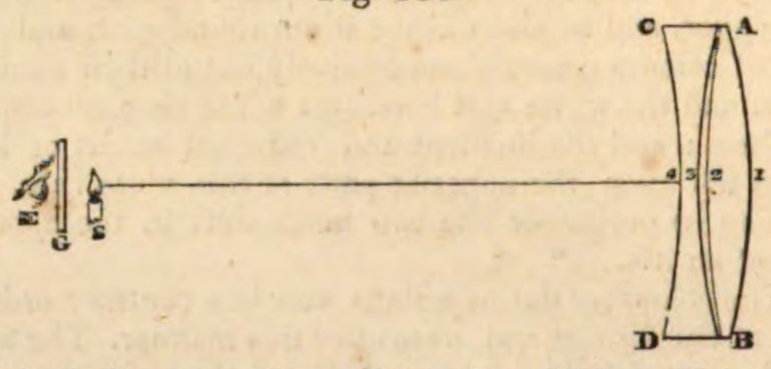
Dr. Thomas Young, in the article CHROMATICS in this work,[1] has given an explanation of these phenomena upon the principles of interference, and Sir John Herschel has shewn by an interesting analysis of them, that they are well fitted for illustrating the laws of this class of phenomena, and may be readily explained by interference.[2]

Fringes in achromatic object-glasses.

When two or three plates are combined, as in the form of concave and convex lenses, and are combined as in the double and triple achromatic object-glass, a series of beautiful systems of rings are developed. The method of observing these rings, and by which Sir David Brewster discovered them, is shewn in fig. 114, where ABCD is the section of the object-

Fig. 114.



glass, including a meniscus of air. A small flame S, is placed about four or five inches from the object-glass, and a small screen G, is interposed between the flame and the eye at E, which is kept as close to S as possible. The distance of the object-glass is then varied, till the inverted greenish coloured flame reflected interiorly from the concave surface A 1 B, seems to cover the whole area of the object-glass. When this takes place, the rings may, by a slight change in the position of the object-glass, or by screening the image formed by the reflection from A and B, be seen in the distinctest manner over the expanded but enfeebled image formed by a second reflexion from the same surface.

When the flame is small, and the eye sees it projected against the centre of the object-glass, the rings form a concentric system, as shewn in fig. 23, Plate CCCLXXXIII, approaching closer and closer to each other, towards the circumference of the lens. Two of these rings *mmmm*, *n*, *n*, *n*, *n*, were distinguished from the rest by their darkness, and by the whiteness of the light between them; and they are the bounding lines of four systems of fringes, into which the general system subdivides itself by oblique reflection; in order to see this change, incline the object-glass so that the point A is farther from the eye than B, and so that the eye may receive the obliquely reflected rays from every point of the surface A and B. At a slight deviation from the perpendicular, the rings become smaller and closer on the side A, and larger and more separated on the side B. At greater incidences the inner ring *aa*, fig. 23, contracts into an irregular crescent *aa*, fig. 24. The second and third rings *bbcc*, fig. 23, do the same, as shewn at *bbcc*, fig. 24; and at a greater incidence the dark ring *nn*, fig. 23, assumes a similar form *nnnn*, fig. 24, and forms the boundary of the *remote central system*, *ncbaabcn*. In like manner the lower part of the ring *nn*, fig. 23, has enclosed a smaller but similar system of rings, which are shewn at *n′n′n′n′*, and may be called the *near central system*. While these changes are going on, the rings without *nn*, fig. 23, are undergoing analogous, though opposite, inflexions. The outermost, *ddd*, fig. 23, divides itself into two unequal portions, which run out into the circumference at the points

Plate CCCLXXXIII. Fig. 23.

Fig. 24.

[1] Vol. vi. p. 636, sect. vi.

[2] *Treatise on Light*, § 688—696. See also Biot's *Traité de Physique*, tom. iv. p. 246.

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ddd'd', fig. 24. Then the next ring, viz. the dark one, *m*, *m*, *m*, *m*, forming the boundary of the *remote external system*, *m*, *m*, *m*, A, and of the *near central system m'*, *m'*, *m'*, B. The four groups of rings thus developed, assume at greater incidences the character shewn in fig. 25, but they are not seen all at once; and in tracing their form it is necessary to cause the image on which they are produced to be reflected successively from different parts of the lens. The rings are so closely packed together, at a distance from the white centres *x'x*, to which they are all related, that it is extremely difficult to perceive them in the present object-glass. At a still greater angle of incidence, the rays close in upon the centres *x'x*, and become exceedingly close and nearer as the points *x'x* approach to the circumference of the lens, and the rays become brighter from the increase of the light at greater obliquities.

Plate CCCLXXXIII. Fig. 24. Fig 25.

In some double object-glasses the rays can only be seen by looking through the convex crown glass lens. In one object-glass the four bounding fringes at *xx*, fig. 25, united and formed a black cross, as shewn in fig. 26. From a series of experiments Sir David Brewster has found that in the object-glass shewn in fig. 113, the action of the two surfaces 1, 2 of the convex lens AB, and the inner surface 3 of the concave one CD, are necessary to the production of these fringes, and hence he concludes that the rings arise from the interference of two pencils of light, one of which has suffered *three* reflections within the convex lens AB, and has passed *four* times through its thickness, with another pencil which has suffered *two* reflexions within the convex lens, and *one* reflexion from the inner surface of the concave lens, and has passed *four* times through the thickness of the convex lens, and *twice* through the thickness of the meniscus of air.

Fig. 26.

In a triple object-glass, which gave a system of rings similar to that in fig. 26, they were covered with *another system of very minute fringes*, parallel to one another, and to the line joining the centres *x* and *x*.[1]

Sect. VI.—*On the Colours of Double Plates of Glass of Unequal Thickness, and other Analogous Phenomena.*

Colours of double plates of unequal thickness.

Mr. W. Nicholson observed the colours of thick plates in the glasses employed for the sights of sextants, and he considered them analogous to those of thin plates. They have been ascribed, however, by Dr. Young,[2] "to the rays twice reflected in the second plate only."

Mr. Knox.

Mr. Knox of Belfast[3] has described some interesting phenomena already briefly noticed by Dr. Young, in the article Chromatics. Having formed a system of the rings of thin plates, by placing a convex lens on a piece of silvered glass, he observed the common system of reflected rings, and also the transmitted system reflected to his eye by the silvered glass. This is shewn in fig. 27, Plate CCCLXXXIII. where A and B are the two systems; but he was surprised to observe between them a system of parallel fringes CD EF, passing through the intersection of the two circular systems. These fringes were equal in number to the number of the rings in A and B. They were equidistant, reached the edge of the lens on both sides, and were formed at right angles to the direction of the light, and to a line forming the centres of the systems A and B.

Fig. 27.

Our author then tried the effect of combining two primary systems of reflected rings in the same manner. With this view he placed a double-convex lens about thirty-six inches in focal length, on a piece of plate glass, with its under side painted black, and upon the lens he placed a piece of plate glass. By these means two sets of primary rings were produced, whose relative positions could be altered at pleasure. By using the shadow of a black card, he found that, instead of parallel fringes, as in fig. 27, he had a new species of rings of a circular form, from two to three times the diameter of the primary rings from which they originated. These rings passed, as before, through the intersections of the primary ones; and the ring which divided the two classes passed through a point, whose distance from the centre of each primary set were in proportion to their longest diameters.

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These rings, which Mr. Knox calls *intersectionary* ones, may be made to vary infinitely in their dimensions, according as the diameters of the primary sets differ more or less, being least where that difference is greatest, and increasing in size as the two primary sets approach to equality, until at last they become straight lines, when the two primary sets are equal. The dimensions of the intersectionary rings will also, as Mr. Knox remarks, *ceteris paribus*, diminish as the two primary sets approach, and increase as they recede from one another.

As these intersectionary rings are almost always accompanied by a second, and sometimes by a third set of equal or unequal dimensions, Mr. Knox supposes that they may be produced by primary sets, combined with either transmitted or reflected sets, provided the two between which they are formed are of unequal dimensions.

Considering the intersectionary fringes as diagonals to the angles at which they were formed, Mr. Knox conjectured that if he could form rectilineal fringes by flat plates, and combine them at different angles, he would produce a third or diagonal set placed between the other two. He accordingly took a pair of slips of glass, and by applying two of their ends together, and using some friction, and a considerable degree of pressure, he formed a fine set of rectilineal fringes. By applying a third slip of glass longitudinally to the upper one of the first two, he formed a similar set of rectilineal fringes at right angles to the first; and he immediately observed the diagonal fringes, which he had anticipated, appear in the angle between the two primary sets, as shewn in fig. 28, where B and C are the primary fringes, and D the intersectionary set, divided into two classes, as shewn by the dotted line. By forming the second set of fringes at different angles with the first, the central band of the intersectionary fringes always bisected the angle. It is a curious circumstance, that though the diagonal fringes are formed by the crossing of the two primary sets, yet they never appear at the opposite angle A, nor could they be made to appear in any angle formed by primary fringes, unless these fringes were so disposed as to have their red sides turned towards each other.

Plate CCCLXXXIII. Fig. 28.

Dr. Young has given an explanation of these curious phenomena in the article Chromatics,[4] to which we must refer the reader.

Dr. Young

Mr. Henry Fox Talbot upon superposing two films of blown glass and viewing through them a homogeneous yellow flame, and even the light of the sky, observed bright and dark stripes, or coloured bands and fringes, which were not produced by either of them separately. These phenomena, as Sir John Herschel remarks, are obviously referable to the same principle as the fringes discovered by Sir David Brewster, "the interference taking place here between rays respectively twice reflected within the upper lamina, and once reflected at the upper surface of the lower lamina, or else between rays, one of which is thrice reflected in the mode represented by A*a*B'*a'* B'*a*A, and the other in that represented by A*a*B'*a*A'*a'*A, the interval between the glasses being supposed to be exactly equal to the

Mr. Fox Talbot.

[1] *Edinburgh Transactions*, vol. xii. p. 191. [2] Art. Chromatics. vol. vi. p. 636. [3] *Phil. Trans.* 1815, p. 161. [4] Vol. vi. p. 636.

Periodical Colours.

thickness of the upper one in both cases, a condition which is sure to obtain somewhere when the laminæ are curved."[1]

Sect. VII.—*On the Colours of Fibres formed by Reflexion and Transmission.*

Colours of fibres.

Every person must have observed the fine thread or line of the spider's web glittering with the brightest colours, when the light of the sun is reflected from it to the eye. By examining these colours attentively, they are found to vary with the angle of incidence. The only attempt that we know of to explain this phenomenon, that deserves notice, is that of Sir John Herschel:—"These colours," says he, "may arise either from a similar cause, (namely, that which produces colour in a single scratch or fissure, or the interference of light reflected from its opposite edges,) or from the thread itself as spun by the animal, consisting of several agglutinated together, and thus presenting not a cylindrical but a furrowed surface." That the structure thus assumed would produce colours cannot be doubted, but they would be the colours of grooved surfaces such as we have already described, which we conceive to be exceedingly different from those of the spider's line.

It appears from a preceding section, that when a reflecting surface has its breadth reduced to an extreme degree of narrowness, whether it be a metallic or a transparent one, it is no longer capable of reflecting white light, but decomposes it in the manner already described, the coloured bands being transverse to the direction of the reflecting line. Sir David Brewster has therefore applied this new property of reflecting surfaces to account for the colour of the spider's line, which presents analogous phenomena, and which from its extreme minuteness, must necessarily decompose white light. If this is not the true cause of the phenomenon, it will not be easy to obtain any rational explanation from the doctrine of interference, without taking for granted the existence of a structure of a very peculiar kind.

On the Colours of Fibres by transmitted Light.

If we take a number of fibres of wool, and fix them in parallel directions, as in Fraunhofer's gratings, they would of course produce parallel spectra or coloured bands similar to those already described. If we take a mass of the same wool, in which the fibres have every possible direction, they will then exhibit spectra or fringes lying in every possible direction, or circular ones. As both these results would be equally obtained, if the fibres were cut down into particles as long as they are broad, we should have parallel fringes when the particles are arranged in straight lines, and circular ones when the particles are scattered like dust upon a plate of glass in all directions. Hence fibres of minute particles will produce circular fringes, which increase in diameter as the particles are smaller in diameter.

When we therefore look at a candle placed at a little distance, through wool, or cotton, or vapour lying upon glass, or diluted blood, or milk, or the seed and farina of plants, &c. &c., we observe round the image of the candle a light area terminating in a *dark reddish* margin. This is followed by a ring of *bluish green* light, and then a *red* ring, and when the fibres or particles have an uniform size, the green and red rings are frequently repeated. It is to Dr. Young that we owe the discovery that the diameter of these rings is always the same when the size of the particles or fibres is uniform and equal, and that they vary inversely as the size of the fibres or particles. On this principle he constructed his *eriometer* for measuring the diameter of minute particles and fibres, such as *wool*, &c. It is composed of a plate of brass, or copper, or even card, with an aperture in the centre about the fortieth of an inch in diameter, and surrounded by a circle of perforations about half an inch in diameter, the number of perforations in the circle being about ten or twelve, and as minute as possible. When the instrument is constructed on such a small scale, the eye requires the aid of a lens. The wool, or plate of particles, are then attached to the end of a slider, and when the light of an argand lamp, or two or three candles placed in a line, so as to unite their flames, is transmitted through the wool or particles, the slider is drawn out till the first *dark red* coloured circle coincides with the circle of particles, and the index then shews on the scale upon the slider the number which indicates the size of the fibres or particles. The basis of this scale, rather an imperfect one, Dr. Young took from Dr. Wollaston's measure of the magnitude of the seeds of the *puff ball* or *Lycoperdon bovista*, which he found to be the 8500ths of an inch in diameter. Dr. Young found the rings formed by these minute seeds to be three-and-a-half on the scale of his instrument, and hence he assumes the *thirty thousandth* part of an inch, (more accurately the 29750th), as the value of an unit on his scale. The following results were obtained by Dr. Young:—

Dr. Young's eriometer.

Table of the diameter of Fibres and minute particles.

Milk diluted, very indistinct, about	3
Lycoperdon bovista, dust of, very distinct	3½
Blood of a bullock, from beef	4½
Human blood, diluted with water	5
Smut of barley (male ear)	6½
Blood of a mare	6½
Human blood diluted with water after standing five days	6½
Blood recently diluted with serum, only	8
Pus	7½
Silk, very irregular	12
Wool of the beaver, jointed, very uniform	13
Angola wool, about	14
Vigonia wool	15
Siberian hare's wool, Scotch hare's wool, foreign coney wool, yellow rabbit's wool, about	15½
Mole's fur	16
Skate's blood	16
British coney wool, American rabbit's wool, about	16½
Saxon wool, a few fine fibres	17
Buffalo's wool	18
Wool of the mountain sheep, *ovis montana*	18
Seal wool, finest, mixed, about	18½
Shawl wool	18 or 19
Goat's wool	19
Cotton, very unequal	19
Peruvian wool, mixed, the finest locks	20
Welch wool, a small lock of	20
Saxon wool	23 or 24
Wool of an Escurial ram	23 to 24
Southdown wool	24½
Lioneza wool, 24 to 29	generally 25
Paular wool, 24 to 29	generally 25½
Alpacca wool, about	26
Laurestinus, farina of	26
Ryeland merino wool	27
Merino Southdown wool	28
Lycopodium seed, beautifully distinct	32
Southdown ewe wool	39
Coarse wool, Sussex	46
Coarse wool, from same, worsted	60

The diameter of the fibres or particles in the preceding table may be obtained in parts of an inch, by dividing the $\frac{1}{30{,}000}$ of an inch by the numbers opposite them. The diameter of the particles of the human blood will be

[1] *Treatise on Light*, § 693. See also *Biot, Traité de Physique*, tom. iv. p. 246.

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$\frac{1}{30,000}$ divided by 5, or the 6000th part of an inch. Dr. Young has ingeniously observed, that if we square the number belonging to the pound of wool, and substract 325, the remainder will be nearly the number of pounds of wool that are worth 100 guineas. In the case of good Lioneza wool for example, whose number is 25, we shall have $25 \times 25 - 325 = 300$ for 100 guineas, or seven shillings per pound.[1]

In experiments of this kind it would be better to express the magnitude of the first ring in parts of the radius, or by the angle which the whole ring subtends at the eye. Those who have any of Mr. Barton's scales, with the number of lines in an inch marked, can easily compare the diameter of the first ring produced either by fibres or particles, with the distance of the red spaces in the two first prismatic images; and by the rule of proportion he will find the magnitude of the fibres or particles.

Sect. VIII.—*On the colours of mixed plates.*

Colours of mixed plates.

Mazeas.

The phenomena of colour observed by M. Mazeas, when he pressed between two glasses, suet, Spanish wax, resin, common wax, and the sediment of urine, are *clearly those of mixed plates*, though they have not hitherto been recognised as such. He put between his glass plates a little ball of suet about one-fourth of a line in diameter, and pressed it between the two surfaces, warming them at the same time in order to disperse the suet. He then rubbed them violently together in a circular manner, and was surprised at looking at a candle through them to see it surrounded with two or three concentric rings, very broad, and with very lively and delicate colours, namely, a red inclining to yellow, and a *green* like that of an emerald. By continuing the friction, the rings assumed the colours of *blue*, *yellow*, and *violet*, especially when he looked through the glasses on bodies directly opposed to the sun.

M. Mazeas[2] shews very clearly that these were not the colours of thin plates on account of the distance between the glasses, and also because the colours disappeared by melting the suet, but a new species of colours which he tried in vain to explain.

Dutour.

M. Dutour[3] repeated and varied the experiments of Mazeas, but did not succeed in explaining them.

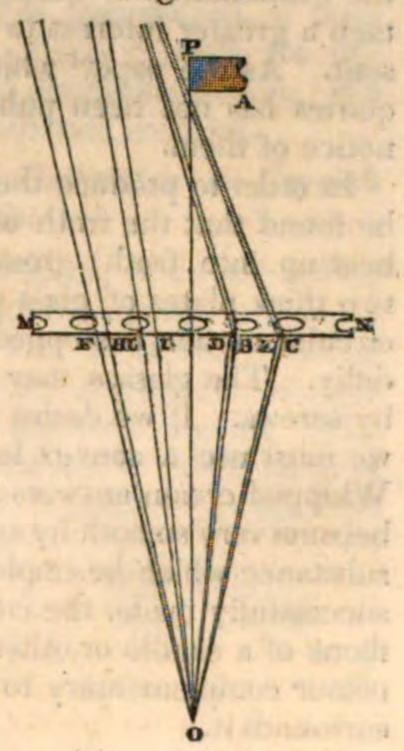
Dr. Young.

Dr. Thomas Young, apparently without knowing of the experiments of Mazeas, though they are fully detailed by Priestley, has described the very same colours under the name of the *colours of mixed plates*, and the merit of discovery of these colours has been ascribed to him by almost all modern writers. The method of producing the colours by suet, as given above by Mazeas, is exceedingly simple, while many persons have failed in repeating the experiments described by Dr. Young. It is to Dr. Young, however, that we owe the higher obligation of having discovered the general principle to which these colours must be referred, though he has not examined the phenomena with that attention which they merited. The following is the account which Dr. Young has given of the colours of mixed plates.

"I first noticed the colours of mixed plates, in looking at a candle through two pieces of plate glass, with a little moisture between them. I observed an appearance of fringes resembling the common colours of thin plates; and, upon looking for the fringes by reflection, I found that these new fringes were always in the same direction as the other fringes, but many times larger. By examining the glasses with a magnifier, I perceived that wherever these fringes were visible, the moisture was intermixed with portions of air, producing an appearance similar to dew. I then supposed that the origin of the colours was the same as that of the colours of halos; but, on a more minute examination, I found that the magnitude of the portions of air and water was by no means uniform, and that the explanation was therefore inadmissible. It was, however, easy to find two portions of light sufficient for the production of these fringes; for the light transmitted through the water, moving in it with a velocity different from that of the light passing through the interstices filled only with air, the two portions would interfere with each other, and produce effects of colour according to the general law. The ratio of the velocities, in water and in air, is that of 3 to 4; the fringes ought therefore to appear where the thickness is 6 times as great as that which corresponds to the same colour in the common case of thin plates; and, upon making the experiment with a plain glass and a lens slightly convex, I found the sixth dark circle actually of the same diameter as the first in the new fringes. The colours are also very easily produced, when butter or tallow is substituted for water; and the rings then become smaller, on account of the greater refractive density of the oils; but, when water is added, so as to fill up the interstices of the oil, the rings are very much enlarged; for here the difference only of the velocities in water and in oil is to be considered, and this is much smaller than the difference between air and water. It appears to be necessary for the production of these colours, that the glasses he held nearly in a right line between the eye and the common termination of a dark and luminous object; the portion of the rings, seen on the dark ground, is then more distinct than the remaining portion; and, instead of being continuations of the rings, they exhibit every where opposite colours, so as to resemble the colours of common thin plates seen by reflection, and not by transmission. In order to understand this circumstance, we must consider that where a dark object as A is placed behind the glasses, the whole of the light which comes to the eye, is either refracted through the edges of the drops, (as the rays B, C,) or reflected from the internal surface (as D, E,) while the light which passes through those parts of the glasses which are on the side opposite to the dark object, consists of rays refracted as before through the edges, (as F, G,) or simply passing through the fluid, (as H, I.) The respective combinations of these portions of light exhibit a series of colours of different orders, since the internal reflection modifies the interference of the rays on the dark side of the object, in the same manner as in the common colours of thin plates seen by reflection. When no dark object is near, both these series of colours are produced at once; and since they are always of an opposite nature at any given thickness of a plate, they neutralize each other, and constitute white light.

Periodical Colours.

Fig. 115.



In applying the general law of interference to these colours, as well as to those of thin plates already known, it is impossible to avoid a supposition which is a part of the undulatory theory, that is, that the velocity of light is the greater, the rarer the medium; and there is also a condition annexed to this explanation of the colours of mixed plates, as well as to that of the colours of simple thin plates, which involves another part of the same theory; that is,

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[1] See Dr. Young's Introduction to Medical Literature, p. 552.

[2] *Memoires Presentées*, tom. ii. p. 43.

[3] Id. Id. tom. iv. p. 288, 289; or Priestley *On Vision*, vol. ii. p. 505.

Periodical Colours.

that where one of the portions of light has been reflected at the surface of a rarer medium, it must be supposed to be retarded one half of the appropriate interval; for instance, in the central black spot of a soap bubble, where the actual lengths of the paths very nearly coincide, but the effect is the same as if one of the portions had been so retarded as to destroy the other. From considering the nature of this circumstance, I ventured to predict, that if the two reflections were of the same kind, made at the surfaces of a thin plate of a density intermediate between the densities of the mediums containing it, the effect would be reversed, and the central spot, instead of black would become white; and I have now the pleasure of stating, that I have fully verified this conclusion by interposing a drop of oil of sassafras between a prism of flint-glass and a lens of crown-glass; the central spot seen by reflected light was white, and surrounded by a dark ring. It was however necessary to use some force, in order to produce a contact sufficiently intimate; and the white spot differed, even at last, in the same degree from perfect whiteness, as the black spot usually does from perfect blackness. There are also some irregularities attending the phenomena exhibited in this manner by different refracting substances, especially when the reflexion is total, which deserves farther investigation."

Recent experiments.

We are not aware that these interesting experiments of Mazeas and Dr. Young, have been repeated by any modern writer, our treatises on optics containing merely an abstract of Dr. Young's results. The subject has, however, been recently taken up by Sir David Brewster, who had found that the *colours of mixed plates*, in place of being merely the result of an experiment, was a *natural phenomenon* of a very interesting kind, which frequently presented itself in the examination of minerals. He was therefore led to attach a greater interest to the phenomena which they present. As the paper[1] which contains the results of his inquiries has not been published, we can only give a brief notice of them.

In order to produce these colours so as to be permanent, he found that the froth of albumen, (the white of an egg beat up into froth) ground circularly as it were between two thick plates of glass pressed firmly together, when the circular motion is stopped, exhibits the colours very splendidly. The glasses may then be held together by wax or by screws. If we desire to have a circular system of rings, we must use a convex lens in place of one of the plates. Whipped cream answers also very well; but paste that has become very smooth by age he found preferable to any other substance which he employed. When the experiment is successfully made, the colours are extremely splendid, the flame of a candle or other luminous body being of a bright colour complementary to that of the coloured light which surrounds it.

Upon looking with a microscope at the albumen or paste thus pressed into a film, it is found to resemble accurately the strata of cavities containing the new fluids, and sometimes water, as in *sulphate of lime*, &c., the paste being sometimes found in separate ramified patches of all shapes surrounded with air, while on some occasions numerous air cavities are included in the paste.

Although Dr. Young was correct in ascribing the colours of mixed plates to the interference of rays moving with different velocities in passing through the two contiguous media, yet his analysis of the phenomena is imperfect, and his determination of the interfering pencils incorrect. In his 39th lecture he ascribes "the colours seen in the dark part beyond the object, to the light scattered irregularly from the surfaces of the fluid,"[2] and in his description of fig. 115, above quoted, he specifies as the interfering portions which produce the colours, viz. *rays reflected* from the internal surface of the cavities, with *rays refracted* through the edges of the drops; and *rays refracted* through the edge with rays *simply passing* through the fluid. That the colours of mixed plates are not produced either by refracted or reflected pencils, is at once proved by the fact, that the same colours may be produced when the most refracting medium is terminated by a fine edge, and is itself a plate with perfectly parallel surfaces, so that there is no edge to reflect light, and no inclined faces to refract it. Having obtained this result, Sir David Brewster viewed the subject in another aspect, and has shewn that the phenomenon is entirely one of inflexion caused by the edge of a transparent inflecting body sufficiently thin to produce colours by the interference of the retarded light passing through the body close to its edge, with the light passing within the body close to its edge. The same pencils which interfere in the common case of a diffracting body interfere in the present case; but the pencils that pass through the transparent plate are modified by the retardation which they experience, so as to produce the phenomena of colours. The oppositely coloured pencils in mixed plates form part of the system of diffracted fringes, the colour seen upon the luminous body occupying the shadow of the diffracting edge, and the opposite colour seen around or beside the candle occupying the first fringe on each side of the shadow. The colours in the fringe on the left hand of the shadow of the diffracting edge, are seen by the eye on the right hand side of the candle, and those in the fringe on the right hand of the shadow are seen by the eye on the left hand side of the candle.

All the preceding phenomena may be produced by breaking down a thin transparent plate into minute portions, and when these portions are made to float in a fluid, or are placed between two plates of glass containing a fluid of nearly the same refractive power as the solid portions. The solid portions will thus act like much thinner plates placed in air, and we shall observe the identical phenomena which take place with the cavities in paste or albumen. When we examine with the microscope a very narrow portion of the solid substance bounded by lines nearly parallel, we perceive the phenomena of mixed plates under a new aspect. The space between the shadow of the two edges is filled up with a bright band of the colour which occupies the two first external fringes, and as the innermost fringe of each edge overlap each other, the colour has double the intensity. The same phenomenon is often seen in the parallel ramifications, or in the long cavities produced by the paste or albumen when the last act of friction was to move one of the plates of glass in a straight line.

The phenomena of mixed plates have been discovered by Sir David Brewster in *sulphate of lime*, in which there are shallow crystallised cavities in great numbers forming regular strata in the mineral. These cavities are filled with water, and in this case the diffracting edge is the edge of the cavity, and the light which passes through the water has its velocity greater than that which passes through the solid mineral.

In one remarkable circular stratum of cavities, all the cavities in the centre were the deepest, and gradually diminished in depth towards the circumference, till the microscope could scarcely resolve them. The highest orders of colours were therefore in the middle of the stratum, and they gradually descended to a white of the first order, at the circumference of the circular stratum.

An interesting experiment lately published by Henry Fox Talbot, Esq.[3] is a phenomenon of mixed plates, in which the densest of the plates is too thick to produce the colours at its edge in common light. "Make," says he, "a circular hole in a piece of card, of the size of the pupil

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[1] This paper will probably appear in the *Phil. Trans.* for 1838, part i.
[2] *Elements of Natural Philosophy*, vol. i. p. 470. [3] *Lond. and Ed. Phil. Mag.* May 1837, p. 364.

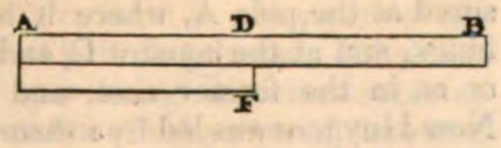
Double Refraction.

of the eye. Cover one half of this opening with an extremely thin film of glass (probably mica would answer the purpose as well or better.) Then view through this aperture a perfect spectrum formed by a prism of moderate dispersive power, and the spectrum will appear covered throughout its length with parallel obscure bands resembling the absorptions produced by iodine vapour. The cause of this phenomenon probably is, that one half of the light which passes through the glass film has its undulations thereby retarded by a certain quantity."

This phenomenon, which we have observed under various modifications, arises from the diffraction of the light passing on each side of and very close to the edge of the film; for if we cover this edge even with a fine wire, we obstruct the diffracted fringes modified by the retardation of the denser plate, and the phenomenon vanishes. Hence in order to see the fringes in perfection, we must make the aperture no wider than to include the space on each side of the edge of the film within which the light passes that is concerned in the phenomenon. As the light here used is perfectly homogeneous, the bands are alternately coloured and obscure.

Sir David Brewster has observed the fringes described by Mr. Talbot with thick plates having fine edges, and immersed in fluids, and even with plates of glass the 15th part of an inch thick, by looking through their edge upon a highly dispersed spectrum formed by a large refracting angle of a prism, and magnified by a powerful telescope. The perfection of the edge of the film, and an equality of thickness, are essential to the production of the fringes in their most interesting form. Sir David Brewster obtained them by looking through plates of sulphate of lime, where there were not properly speaking plates of different refractive powers, but where the plate suddenly became thicker, as shewn in the annexed figure, where AB, EC is the plate of sulphate of lime, which becomes thicker at E. When the eye looks through it at the spectrum in the direction ED, it sees the fringes which have the same magnitude as if the plate ADB were removed, and the eye looked only through the plate CE, in which case it is clearly a phenomenon of mixed plates.

Fig. 116.



When these dark lines were produced in great perfection, they had a sort of granular structure resembling fine screws at their edges, and sometimes appearing to enclose minute specks of light. Several other remarkable phenomena accompanying these fringes were communicated by the author to the British Association at Liverpool, and will appear in the next volume of the Philosophical Transactions.

PART. VI.—ON THE DOUBLE REFRACTION OF LIGHT.

Double refraction.

In the preceding part of this article we have supposed that when light is transmitted vertically through the surfaces or through the mass of transparent bodies, or when it passes obliquely and is refracted by the same bodies, it leaves the surface or emerges from the body in a single pencil, either perfectly white, or decomposed into a diverging beam of coloured light. This supposition is perfectly correct, under certain circumstances, for gaseous and fluid bodies, for glass slowly and equally cooled, and for a numerous class of crystallized bodies, whose primitive form is either the *cube*, the *regular octohedron*, or the *rhomboidal dedecahedron*. When these bodies have the same temperature and density throughout their mass, and are not exposed to any pressure, a pencil of light will be transmitted through them *single*, according to the laws already explained.

Double Refraction.

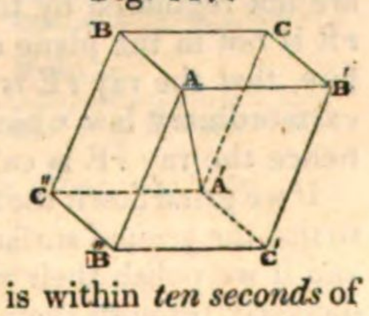
When a pencil of light falls upon all other bodies, such as artificial crystals, or salts on crystallized minerals, which have not the above primitive forms; upon animal substances, such as bone, horn, shell, hair, crystalline lenses of animal and elastic integuments; upon vegetable bodies, such as particular leaves, stalks and seeds; upon artificial bodies such as gums, resins, jellies, and solid bodies that have a variable density, during the transient passage of heat, or from rapid cooling, or unequal temperature and pressure:—when a pencil of light falls upon such bodies, it will be refracted into two distinct pencils, more or less inclined to each other according to the mechanical condition of the body, or to the direction in which the pencil passes through it. In some minerals and artificial crystals, this refraction of the two pencils is very great, and, generally speaking, is in such crystals, easily observed and measured; but in some cases it is not visible unless by transmitting the light through prisms of the body with large refracting angles; and in very many cases, the existence of two pencils is inferred only from certain other properties, which always accompany the property of giving double pencils. This separation of a single pencil into two, is called *double refraction*, and the bodies which have such a property are called *doubly refracting crystals* or *bodies*.

In many regular crystals there is *one line* through which, if a single pencil of light is transmitted, it does not experience double refraction. This line is called the *axis of the crystal*, or the *axis of double refraction*, and such crystals are denominated crystals with one axis of double refraction. In other crystals there are two lines through which, if the single pencil of light is transmitted, it does not experience double refraction. Such crystals are denominated crystals with two axes of double refraction. We shall treat of these two classes in separate sections.

SECT. I.—*On the Law of Double Refraction in Crystals with one Axis.*

As Bartholinus discovered the property of double refraction in the mineral called *Iceland spar*, *calcareous spar*, or by chemists, *carbonate of lime;* and it is well fitted for exhibiting the phenomena, owing to its perfect transparency, and the great separation of the two pencils, This mineral consists, according to Stromeyer, of 56·15 parts of lime, and 43·7 of carbonic acid. It crystallises in the form of an obtuse rhombohedron, as shewn in fig. 117, where ABCB, ABCB, &c. are the faces of the rhombohedron, and AA′, the axis of the rhombohedron, on the two joining its two obtuse angles. The following are the dimensions of the crystal, as given by Malus, who observes that the first angle, from which all the rest are derived, is within *ten seconds* of the truth.

Fig. 117.



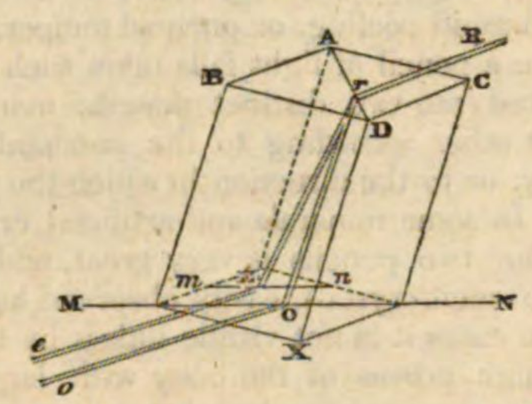
Inclination of the faces ABCB′, AB′C′B″....	105°	5′	
Inclination of the faces ABCB′, A′CBC″....	74	55	
Plane angle between the edges AB, AB′....	101	55	
——— AB, BC.....	78	4	59″
Inclination of the faces to the axis AA′.....	45	23	26
Angle between the edges AB, AB′, &c. and the axis AA′.....	66	44	45
Inclination of the edges AB, AB′, to the opposite faces AB′CB″, &c.....	109	8	12
——— A′C, A′C, to the opposite faces ABCB′.....	70	51	48
Length of the diagonal AA′, the sides AB AC being unity.....	1·2598		

Double Refraction.

As Iceland spar cleaves equally in planes parallel to all its six faces, it is easy to cut out of any mass of it an accurate rhombohedron in which all the three sides AB, A′B, A″B″, are equal; but for the purposes of experiment it is sufficient to have a piece with two smooth and parallel faces formed by cleavage, or ground and polished parallel to the cleavage planes.

Let AX be such a piece of Iceland spar, and ABDC its upper surface. If we place its lower surface upon a piece of paper having a black line MN, drawn upon it, and if we place the eye above the upper surface, we shall see the line MN distinctly doubled; or if it should appear single, the two images will separate, by turning the spar a little round, and the line will appear double as at MN, and *mn*. The one line will be found to coincide with the other, when MN is parallel to AD, the short diagonal of the rhomboidal face ABDC, and the lines will appear most separated, when MN is parallel, as in the figure, to the long diagonal BC. If a black spot is used in place of a line placed at O, it will appear double in every position, and in turning the crystal round, the other image E will seem to revolve round O.

Fig. 118.



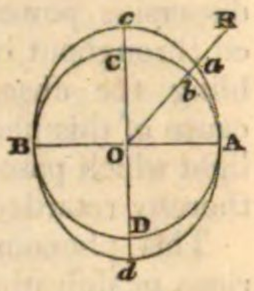
The best way, however, of shewing the double refraction of the Iceland spar, is to make a ray of light R*r*, fall upon the crystal at *r*. This ray will be refracted into two pencils or rays, *r*O, *r*E, and these will be again refracted at the second surface of the spar in directions E*e*, O*o*, parallel to the original ray R*r*. If we measure the angles of refraction of the fixed ray O*o*, corresponding to several angles of incidence from 0° to 90°, we shall find that these angles are always to one another in the constant ratio of 1 to 1·654, and that the refracted ray *r*O is always in the plane of incidence. It follows, therefore, that this ray is refracted as in water and glass, according to the ordinary law of refraction discovered by Snellius. Hence it is called the *ordinary ray*. But if we make the same experiments on the other ray *r*E, we shall find that at an incidence of 0°, in place of passing on unrefracted, it is actually refracted 6° 12′; that at other incidences its angles of refraction are not regulated by the law of Snellius, and that the ray *r*E is not in the plane of incidence. We conclude, therefore, that the ray *r*E is refracted according to some new or extraordinary law which remains to be investigated, and hence the ray *r*E is called the *extraordinary ray*.

If we grind down the two solid obtuse angles A, A′, fig. 116, so that the ground surfaces are perpendicular to the axis AA′, and if we polish their surfaces, and transmit a ray perpendicularly through them, so as to be parallel to the axis AA, we shall find that there is only one refracted ray, and hence there is no double refraction along the axis. Now this line AA′ is not a *fixed axis* like that of the earth; it is merely a *fixed direction*; for every line parallel to AA′ enjoys the property of an axis, as there is no double refraction in lines parallel to AA′.

In order to obtain an accurate idea of the law of extraordinary refraction, or that by which the extraordinary ray *r*E is regulated, let us take a rhomb, such as that shewn in fig. 117, and grind it into an accurate sphere, and then polish it. Let ACBD be such a sphere, AB being its axis of double refraction, corresponding with AA′ in fig. 117, and let O be its centre. If we now bend a piece of sheet lead or sheet copper into an arch ADB, and making a small hole in it opposite to A, and another opposite to B, cement a handle to it about D, it will enable us, in the following manner, to detect the general law of extraordinary refraction. The use of the two holes in this experiment is to ensure that the light admitted through one of them, and emerging at the other, shall pass through the centre O of the sphere. Let one of the holes be now placed in the surface of the sphere at A, and the eye at the other hole at B, the hole will appear single, shewing that the double refraction is there nothing. Let the hole be shifted gradually from A to C, and the other hole will move from B to D. In the different positions from A to C, it will be seen that the hole begins to become double on leaving A, and that the distance of the two images of it gradually increases from A to C, where it becomes a maximum. The same result will be obtained by making the hole move from A to D, or in any quadrant of the sphere passing through the poles A and B. The very same result will be obtained if the hole moves from B to C, or from B to D. If we now make one of the holes move along the equator COD, we shall find that by placing the eye at the other hole, the distance of the images will be exactly the same, or the double refraction the same in every part of the equator. Hence the general law of double refraction in crystals with one axis, is a very simple one: it is nothing at the poles; it increases gradually from the poles to the equator, where it is a maximum; it is the same in the same parallels of latitude; and the preceding experiments will also shew that the line joining the centres of the two images is in the plane of the meridian.

Double Refraction.

Fig. 119.



Let the index of extraordinary refraction be now measured at the pole A, where it is the same as the ordinary index, and at the equator C, and it will be found to be 1·654, or *m*, in the former case, and 1·488, or *m′*, in the latter. Now Huygens was led by a theory which has been explained under CHROMATICS, to the following law, which he verified by experiment, and which has been confirmed by the experiments of Wollaston, Malus, and other philosophers. Upon the axis AB of the sphere, fig. 118, describe an ellipse A*c*, B*d*, whose lesser axis AB is to its greater axis *cd* as $\frac{1}{m}$ is to $\frac{1}{m'}$, or as $\frac{1}{1\cdot654}$ is to $\frac{1}{1\cdot488}$, or as ·604 to ·674; and if an oblate spheroid is supposed to be generated by the revolution of this ellipse round its lesser axis AB, the reciprocal of the index of refraction of the extraordinary ray at any point of the spheroid will be measured by its radius at that point; that is, if R*ab*O is a ray incident at *b*, the radius $\frac{1}{Oa}$ will be the extraordinary index of refraction for that ray. If we therefore make

φ = ROA, or the inclination of the incident ray to the axis.
R = *cd*, the major axis of the spheroid.
r = AB, the lesser axis.

Then it may be shewn, as Malus has done,[1] that

$$Oa = \frac{Rr}{\sqrt{(r^2 \sin.^2\varphi + R^2 \cos.^2\varphi)}};$$

[1] *Theorie de la Double Refraction*, p. 143.

Double Refraction.

and as the index of refraction of the extraordinary ray is the reciprocal of this radius, we have

$$m' = \frac{\sqrt{(r^2 \sin.^2\varphi + R^2 \cos.^2\varphi)}}{Rr}, \text{ or}$$

$$m'^2 = \frac{1}{r^2} - \left(\frac{R^2 - r^2}{R^2 r^2}\right) \sin.^2\varphi.$$

In the case of Iceland spar, we have

$$m'^2 = 2{\cdot}736693 - 0{\cdot}536510 \sin.^2\varphi, \text{ or}$$

$$m' = \sqrt{2{\cdot}736693 - 0{\cdot}536510 \sin^2\varphi}.$$

As the index of extraordinary refraction thus found, is always equal to the index of the ordinary refraction *minus*, another quality which depends on the difference between the radius of the sphere and that of the spheroid, the crystals in which this happens may be called *negative* doubly refracting crystals.

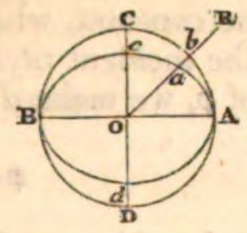
The preceding law of double refraction was believed by Malus to be universal, and applicable to all crystals that had this property. M. Biot, however, discovered that in quartz or rock crystal the extraordinary ray had its index of refraction m' greater than the ordinary index m. This mineral crystallises in six-sided prisms, as shewn in the annexed figure, terminated by six-sided pyramids, A and B. If we grind down and polish the summits A and B of a large crystal, perpendicular to the axis AB, and if we determine the index of refraction when the rays pass along AB, we shall find it to be as Malus found it, 1·5484, and without any double refraction, and 1·5544 in a direction perpendicular to the axis.

Fig. 120.

If we now grind the crystal into a sphere ACBD, fig. 121, and if we perform the very same experiments with it as we did with Iceland spar, we shall obtain analogous results. The double refraction will be found to increase from the poles A, B, to the equator CD, and to be the same in every part of the equator, and in each parallel of latitude; the only differences between it and calcareous spar being that the double refraction is less, and that the index of refraction of the extraordinary ray is always *greater* than that of the ordinary ray.

The extraordinary refraction of quartz will, therefore, as M. Biot has shewn, be represented by a prolate spheroid generated by the revolution of the ellipse AcBd, whose greater axis AB is to the lesser cd as $\frac{1}{1{\cdot}5484}$ is to $\frac{1}{1{\cdot}5544}$, or as ·6458 is to ·6418. Hence, if RbaO is a ray incident on the sphere at b, the radius $\frac{1}{Oa}$ will be the index of extraordinary refraction for that ray. Hence we shall obtain

Fig. 121.



$$Oa = \frac{Rr}{\sqrt{(r^2 \sin.^2\varphi - R^2 \cos.^2\varphi)}}, \text{ and}$$

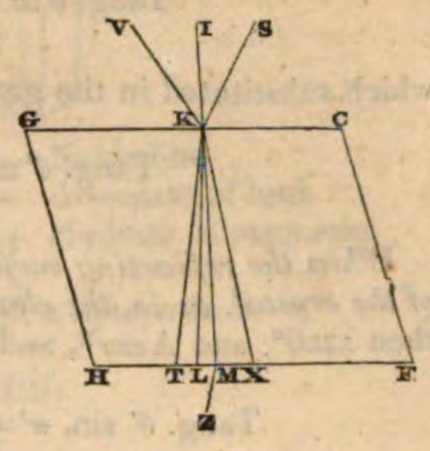
$$m^2 = \frac{1}{r^2} + \frac{R^2 - r^2}{R^2 r^2}, \sin.^2\varphi.$$

Hence, as the index of extraordinary refraction is equal to the index of ordinary refraction, *plus*, another quantity depending on the difference between the radius of the sphere and that of the prolate spheroid, crystals which have this property may be called *positive* doubly refracting crystals.

The following geometrical rule of finding the direction of the extraordinary ray, when the incident ray forms different angles with the axis given by Huygens,[1] may be interesting to some of our readers. Let CGHF be what is called the *principal section* of a crystal of calcareous spar, &c., or a plane passing through the axis, which will be in the direction CH. Let SK, VK, be rays incident on that plane upon the surface CG, and equally inclined to IKL, perpendicular to the surface at the point of incidence K; then if KM is the refracted ray, corresponding to a ray IK, incident perpendicularly, the other rays VK, SK, will be refracted in directions KT, KX, so that TM is equal to XM.

Double Refraction.

Fig. 122.



Although the determination of the extraordinarily refracted ray is very simple, when the crystal is supposed to be spherical, yet the formula becomes complicated when we suppose the ray incident in any given direction upon a natural surface of Iceland spar. Malus has investigated such a formula, but our limits will not allow us to give more than the resulting expression.

Making θ = the angle of incidence,

θ' = the angle of extraordinary refraction,

π = the azimuth of incidence, or the angle which the plane of incidence forms with the axis.

π' = the same angle for the extraordinary ray.

λ = the inclination of a line perpendicular to the face of incidence to the axis of the crystal.

$A = R^2 \sin.^2\lambda + r^2 \cos.^2$,

$C = \sin.\lambda \cos.\lambda\,(R^2 - r^2)$. Then

$$\text{Tang. } \theta' \cos. \pi' = \frac{R^2 r^2 \sin.\theta \cos.\pi}{A\sqrt{A - R^2 \sin.^2\theta\,(r^2 \cos.^2\pi + A \sin.^2\pi}} + \frac{C}{A},$$

and

$$\text{tang. } \theta' \sin. \pi' = \frac{R^2 \sin.\theta \sin.\pi}{\sqrt{A - R^2 \sin.^2\theta\,(r^2 \cos.^2\pi + A \sin.^2\pi.)}}$$

When the refracting surface is parallel to the axis, (as in the six-sided prism of calcareous spar), we shall have $\lambda = 90$, in which case $A = r^2$ and $C = 0$. The formula then becomes

$$\text{Tang. } \theta' \cos.\pi = \frac{r^2 \sin.\theta \cos.\pi}{R\sqrt{1 - \sin.^2\theta\,(r^2 \cos.\pi + R^2 \sin.^2\pi)}}.$$

$$\text{Tang. } \theta' \sin.\pi = \frac{R \sin.\theta \sin.\pi}{\sqrt{1 - \sin.^2\theta\,(r^2 \cos.^2\pi + R^2 \sin.^2\pi)}}.$$

and dividing the one equation by the other, we have

$$\text{Tang. } \pi' = \frac{R^2}{r^2} \text{tang. } \pi.$$

When the refracting surface is parallel to the axis, and the plane of incidence perpendicular to the axis, then $\pi = \pi' = 90°$, or $\lambda = 90$; consequently cos. $\pi' = 0$, and the first equation becomes

$$\text{Tang. } \theta' = \frac{R \sin.\theta}{\sqrt{1 - R^2 \sin.^2\theta}} \text{ and } \sin.\theta' = R \sin.\theta.$$

When the refracting surface is parallel to the axis, and the plane of incidence passes through the axis, in which case the refraction is in the plane of a *principal section*, then $\pi = \pi' = 0°$, the second equation becomes

[1] *Traité de la Lumière*, sect. 17.

Double Refraction.

$$\text{Tang. } \theta' = \frac{r}{R} + \frac{r \text{ sin. } \theta}{\sqrt{1 - r^2 \text{ sin.}^2 \theta}},$$

or, by substituting r sin. θ for its equal sin. θ, we have

$$\text{Tang. } \theta' = \frac{r \text{ sin. } \theta}{\sqrt{1 - r^2 \text{ sin.}^2 \theta}},$$

which substituted in the general formula, gives

$$\text{Tang. } \theta' = \frac{2}{R} \text{Tang. } \theta.$$

When the refracting surface is perpendicular to the axis of the crystal, as in the chaux carbonatée baseé of Hauy, then $\lambda = 0°$, and $A = r^2$, and $C = 0$. Hence

$$\text{Tang. } \theta' \text{ sin. } \pi' = \frac{R^2 \text{ sin. } \theta \text{ sin. } \pi}{r\sqrt{1 - R^2 \text{ sin.}^2 \theta}},$$

$$\text{Tang. } \theta \text{ Cos. } \pi' = \frac{R^2 \text{ sin. } \theta \text{ cos. } \pi}{r\sqrt{1 - R_2 \text{ sin. }^2\theta}}.$$

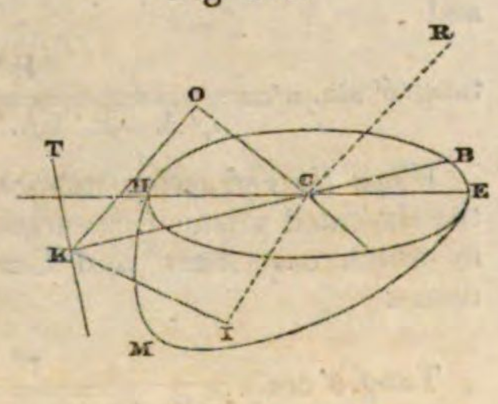
and dividing the one equation by the other we have

Tang. $\pi' =$ Tang. π, and $\pi' = \pi$, which shews that the refracted ray is in the plane of the incident ray. Hence we obtain from the preceding equation,

$$\text{Tang. } \theta' = \frac{R^2 \text{ sin. } \theta}{r\sqrt{1 - r^2 \text{ sin.}^2 \theta}}.$$

In order to find the path of the extraordinarily refracted ray, Huygens has given the following elegant geometrical construction. Let EBH be the elliptical section of the oblate spheroid which regulates the double refraction of the crystal, formed by the surface upon which the ray is incident. Let the ray RC fall upon its centre, and let BCK be the intersection of the plane of incidence with the face of the crystal. Let EMH be a part of the oblate spheroid within the crystal or below its surface, the axis of the spheroid passing through and having any inclination to the surface. Then draw in the plane KCR a line CO perpendicular to RC, and having drawn OK perpendicular to OC, or parallel to CR, make OK equal to $\frac{1}{3m \text{ incid.}}$ or the reciprocal of the sine of the angle of incidence. Through K draw KT perpendicular to the plane of incidence BRCK, and through KT draw a plane which shall touch the spheroid. Let I be the point where this plane touches the spheroid, then drawing the line CI, this line will be the extraordinarily refracted ray.

Fig. 123.



Doubly refracting lenses.

As there are several researches and instruments in which it may be required to find the focus of the extraordinary pencil when the doubly refracting substance has the form of a lens, we shall here give the formula obtained by Malus. Calling r, r' = the radii of the anterior and posterior surfaces of a convex lens,

d = the distance of the radiant point,

a = the larger semi-axis of the spheroid of double refraction.

b = the shorter semi-axis of do.

F = the focal length for the ordinary ray.

f = the focal length of the extraordinary ray, when d is infinite, or the rays parallel, and

φ = the focal length of the extraordinary ray required.

Double Refraction.

Thus Malus has shewn that

$$\varphi = -\frac{a^2 bdrr'}{d(r+r')(26^2 - a^2 - a^2 b) - a^2 brr'};$$

$$F = \frac{-brr'}{(r+r')(1-b)}.$$

When the radii r, r', are equal, or the lens *equally convex*, we have

$$\varphi = -\frac{a^2 bdr}{2d(2b^2 - a^2 - a^2 b) - a^2 br},$$

$$f = -\frac{a^2 br}{2(2b^2 - a^2 - a^2 b}.$$

If we suppose a to be equal to b, or the spheroid to become a sphere, by which the ordinary refraction is regulated, we obtain for the ordinary ray,

$$F = \frac{br}{2(1-b)}.$$

Hence, the difference between the ordinary and extraordinary focal lengths will be

$$f - F = 2F\frac{a^2 - b^2}{2b^2 - a^2 - a^2 b}.$$

If we change the signs of r and r' in these expressions, they will apply to *concave* lenses.

Lenses of Iceland spar.

If we now take *Iceland spar*, and suppose the lens to be formed of that substance, we have only to substitute in the preceding equation, the following values of a and b,[1] viz.:—

$a = 0{\cdot}6741717$
$b = 0{\cdot}6044871$, whence
$m = 1{\cdot}65429$
$m' = 1{\cdot}48330$,

we obtain

$\varphi = -r.\ 8{\cdot}8228602$
$F = -r.\ 0{\cdot}764180$
$f - F = -F.\ 114{\cdot}4546$

In the case of *quartz* or *rock crystal*, where

$a = 0{\cdot}645813$
$b = 0{\cdot}641776$
$m = 1{\cdot}558176$
$m' = 1{\cdot}548435$,

we obtain

$\varphi = -r.\ 0{\cdot}962824$
$F = -r.\ 0{\cdot}895775$
$f - F = -F.\ 0{\cdot}074846.$

In all lenses of the same substance, the ratio of f to F will be constant, whatever be the form of the lenses, provided the incident rays are parallel. If, in the general expression of φ, we make d infinite, we have

$$\varphi = \frac{a^2 brr'}{(r+r')(2b^2 - a^2 - a^2 b)}.$$

and making $a = 0$, we have for the ordinary ray,

$$F = -\frac{brr'}{(r+r')(1-b)},$$

whence

$$\frac{\varphi}{F} = \frac{a^2(1-b)}{2b^2 - a^2 - a^2 b}.$$

a result independent of the values of r and r'.[2]

The focus of the rays refracted extraordinarily by a doubly refracting lens, becomes more and more distant, as

[1] Malus, *Theorie*, &c., p. 278, sect. 66.

[2] Id. Id. p. 281, sect. 66.

Double Refraction.

the axis of double refraction of the crystal approaches to the axis of the lens; and the preceding formulæ apply solely to the case where these two axes are parallel, as it is only in that case that such lenses can be of any use.

List of the Primitive Forms and Crystals which have one axis of Double Refraction.

Crystals with one axis.

From a very extensive series of experiments on the double refraction of crystallised bodies, Sir David Brewster was led to the general law, that all crystals whose primitive form has only *one axis* of figure, or one pre-eminent line, round which the matter of the crystals is symmetrically arranged, had also *one axis* of double refraction, and that their axis of figure was likewise the axis of double refraction.

The following are the primitive forms which possess this geometrical and optical property:—

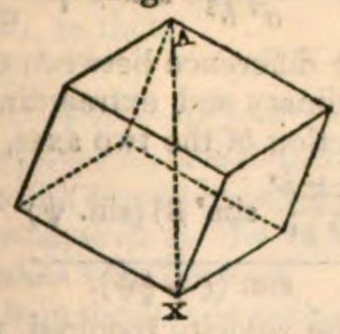
The rhombohedron with an obtuse summit.
The rhombohedron with an acute summit.
The regular six-sided prism.
The octohedron with a square base.
The right prism with a square base.

Table of Crystallised Minerals and other bodies which have one axis of double refraction.

In the following table the crystals are arranged under their primitive forms, so far as these forms have been determined by crystallographers. The sign + indicates that the crystals have *positive* double refraction, like *quartz*, and — that they have *negative* double refraction, like *Iceland spar*.

1. *Rhombohedron with an obtuse summit.*

Fig. 124.



— Carbonate of lime (Iceland spar).
— Carbonate of lime and iron.
— Carbonate of lime and magnesia.
— Phosphato-arseniate of lead.
— Carbonate of zinc.
— Nitrate of soda.
— Phosphate of lead.
— Ruby silver.
— Levyne.
— Tourmaline.
— Rubellite.
— Alum stone.
— Gmelinite.
— Chlorate of soda.
+ Dioptase.
+ Quartz.

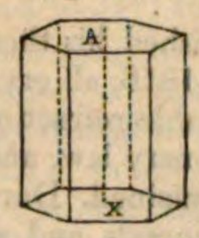
2. *Rhombohedron with acute summit.*

Fig. 125.

— Corundum.
— Sapphire.
— Ruby.
— Cinabar.
— Arseniate of copper.

3. *Regular six-sided prism.*

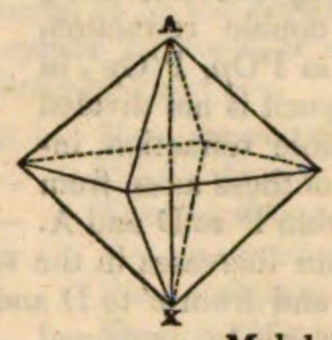
Fig. 126.



— Emerald.
— Beryl.
— Apatite.
— Nepheline.
— Arseniate of lead.
+ Hydrate of magnesia.

4. *Octohedron with a square base.*

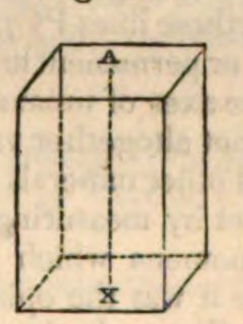
Fig. 127.



+ Zircon.
+ Oxide of tin.
+ Tungstate of lime.
— Mellite.
— Molybdate of lead.
— Octohedrite.
— Muriate of potash.
— Cyanide of mercury.

5. *Right prism with a square base.*

Fig. 128.



— Idiocrase.
— Wernerite.
— Paranthine or scapolite.
— Meoinite.
— Somervillite.
— Edingtonite.
— Arseniate of potash.
— Subphosphate of potash.
— Phosphate of ammonia and magnesia.
— Sulphate of nickel and copper.
— Hydrate of strontites.
+ Apophyllite of Uton.
+ Oxahverite.
+ Superacetate of copper and lime.
+ Titanite.
+ Ice, certain crystals.
Murio-carbonate of lead.

The following crystals and organised bodies have one axis of double refraction, but their primitive form has not been accurately determined.

	Position of the axis.
— Muriate of lime	Axis of six-sided prism.
— Muriate of strontian	Do. do.
— Hyposulphate of lime[1]	Axis of hexagonal tables.
— Mica from	Perpendicular to laminæ.
— Mica, with amianthus	Perpendicular to the laminæ.
— Nacre, (See *Phil. Trans.* 1836, p.)	Perpendicular to laminæ.
+ Boracite	Axis of rhomb of 90°.
+ Apophyllite, (*surcompose* of Hauy),	Perpendicular to the table.
+ Sulphate of potash and iron,	Axis of six-sided prism.
Tortoise shell, (Sir. J. Herschel),	

[1] Sir John Herschel.

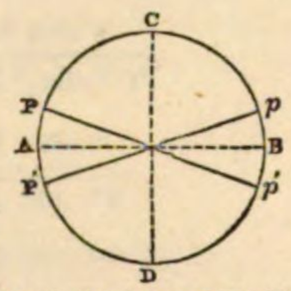
Double Refraction.

SECT. II.—*On the Law of Double Refraction in Crystals with two axes.*

When M. Malus published his theory of double refraction, and even so late as 1816, all crystals were believed to have only one *axis* of double refraction, one of the rays being refracted by the ordinary law, and the other by the extraordinary law, above explained. During the examination of an extensive class of minerals and artificial salts, Sir David Brewster was led to the discovery of crystals with *two axes of double refraction.*

The general character of the phenomena presented by such crystals will be understood from fig. 129, where we may suppose, as before, the crystal to have the form of a sphere. In place of there being one line along which there is no double refraction, there are two such as P*O*p, P′*O*p′, in which the incident pencil is not divided into two. The double refraction increases on each side of these axes, from P, to C and A, and from P′ to D and A. The double refraction increases in the very same manner from *p* to C and B, and from *p′* to D and B, according to a law which will afterwards be explained.

Fig. 129.



In continuing his investigations, Sir David Brewster found crystals in which the axes P*O*p, P′*O*p′ formed all possible angles with each other from 0° up to 90°, and he was led also to the important result, that these two axes were not real axes of double refraction like those in uniaxal crystals, but were only *resultant axes*, as he called them, or *axes of compensation.* The grounds on which he formed this opinion were, that these lines P*O*p, P′*O*p′ had no relation whatever to any fixed or permanent lines in the primitive form of the crystals, like the axes of uniaxal crystals, and that the double refraction did not altogether vanish along these lines, as in Iceland spar and other minerals with no axis. He was led to these results, not by measuring the double refraction itself, but by the phenomena which will be presently explained. At this time it was the opinion of our author, and afterwards that of M. Biot and other distinguished philosophers, that in *biaxal* as in uniaxal crystals, one of the rays was refracted according to the ordinary law of Snellius, and the other according to an extraordinary law, and hence the investigation of the extraordinary law occupied the attention of our author.

In commencing this inquiry, he assumed as the two real axes of double refraction, the line AB bisecting the angle formed by the apparent or resultant axes P*O*p, P′*O*p′, and another line at right angles to it, viz. either the line CD, or the line perpendicular to it passing through O.

If the principal axis AB is *positive*, then if we assume O as the second axis, it must be taken *positive* also; but if CD is assumed as the second axis, it must be taken *negative.* Now, it is obvious that if we take AB as a *positive*, and CD as a *negative* axis, the double refraction in the direction AB is the maximum double refraction of the axis CD, because the effect of the axis AB is here nothing. In like manner, the double refraction along CD is a measure of the maximum double refraction of the axis AB. Hence we can easily ascertain the relative intensities of the doubly refracting force of each axis AB and CD. Having done this, the next step was to compute the double refraction at the point P produced by the positive axis AB acting alone as a single axis, and also the double refraction produced at the same point P, by the negative axis CD. When this was done, the two double refractions were found to be equal and opposite, and hence they compensated each other, and produced an axis P*p*, in which there was no double refraction, and which was the resultant of the actions of AB and CD.

Double Refraction.

In this way, and by experiments which will be related in a subsequent chapter, our author was led to the following method of finding the general law of extraordinary refraction in biaxal crystals.

Make b = axis of revolution of the two spheroids.
a, a' = the other axis of the spheroid.
β, β' = the inclination of the incident ray to the axes of the crystal.
ψ = the angle of the doubly refracting forces emanating from each axis.
ζ = half the difference of the angle at the base of the parallelogram of forces.

Then, as the velocity of the ray is inversely as the variable radius of the spheroid, $\frac{1}{b^2}$ will be the square of the velocity of the ordinary ray, and $\frac{1}{a^2}$, $\frac{1}{a'^2}$ the square of the minimum velocity of the extraordinary ray, in virtue of the separate action of each axis, AB and CD. Hence the difference between the squares of the velocities of the ordinary and extraordinary rays will be

$$\left(\frac{a^2 \pm b^2}{a^2 b^2}\right) \sin.^2 \beta$$

$$\left(\frac{a'^2 \pm b^2}{a'^2 b^2}\right) \sin.^2 \beta$$

the sign being positive when the axis is positive, and *vice versa.* But as these expressions represent the sides of the parallelogram of forces, we have

$$\text{Tang. } \zeta = \frac{\left(\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta\right) - \left(\frac{a'^2 \pm b^2}{a'^2 b^2} \sin.^2 \beta'\right) \text{tang. } \frac{1}{2}\psi}{\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta + \frac{a'^2 \pm b^2}{a'^2 b^2} \sin.^2 \beta'.}$$

Consequently the difference between the squares of the velocities of the ordinary and extraordinary ray produced by the combined action of the two axes, will be

$$\frac{\left(\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta\right)(\sin. \psi)}{\sin. (\zeta + \frac{1}{2}\psi).}$$

Hence, calling V the velocity required, we have

$$V^2 = \frac{1}{b^2} \pm \frac{\left(\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta (\sin. \psi)\right.}{\sin. (\zeta + \frac{1}{2}\psi)}, \text{ and}$$

$$V = \left\{\frac{1}{b^2} + \frac{\left(\frac{a^2 \pm b^2}{a^2 b^2} \sin.^2 \beta\right)(\sin. \psi)}{\sin. (\zeta + \frac{1}{2}\psi)}\right\}^{\frac{1}{2}}$$

The form of the compound, or irregular spheroid, may therefore be computed for all doubly refracting crystals.

The general law of extraordinary refraction which has now been explained, may be thus expressed.

The increment of the square of the velocity of the extraordinary ray produced by the action of two axes of double refraction, is equal to the diagonal of a parallelogram whose sides are the increments of the square of the velocity produced by each axis separately, and calculated by the law of Huygens, and whose angle is double of the angle formed by the two planes passing through the ray and the respective axes.

When the two axes are of equal intensity, and of the same character, the preceding law gives the very same results as the law of Huygens does for one axis placed at right angles to the other two.

From these views it follows as a necessary consequence, a consequence first deduced from them by M. Biot, that the difference of the squares of the velocities of the two rays are proportional to the product of the sines of the

Double Refraction.

angles which each of them make with the two resultant axes P and P′, and hence making these angles φ and φ', and V the velocity of the extraordinary, and v that of the ordinary ray, we shall have $V = (v^2 + a \sin.\varphi \times \sin.\varphi')^{\frac{1}{2}}$, a being a constant coefficient.

M. Fresnel's law.

M. Fresnel was led by theoretical considerations to suppose that in crystals with two axes, the law of double refraction was still more complicated; and he soon confirmed the accuracy of his views by direct experiment, and was thus able to establish a general law which embraced all crystals with one axis.

Our limits will not allow us to do more than give the following brief abstract of his labours, which we owe to M. Pouillet.[1]

When the light is incident in the plane perpendicular to AB, fig. 129. that is in the plane of CD, *one* of the *two* rays is regulated by the ordinary law of refraction, whereas when the ray is incident in the plane AB, perpendicular to the axis CD, the *other* of the two rays is regulated by the ordinary law of refraction. The formulæ by which Fresnel expressed his law, are as follow:

making V=the velocity of the ordinary ray.
v=that of the extraordinary ray.
A=the angle of the ray with the one axis.
a=the angle of the ray with the other axis.
D=*ordinary* velocity in *uniaxal* crystals, or the *constant* velocity in the section perpendicular to CD, fig. 129, in *biaxal* crystals.
d'=the *extraordinary* velocity in *uniaxal* crystals, or the *constant* velocity in the section perpendicular to AB, fig. 129, then

$$V^2 = D^2 + (d^2 - D^2)\sin^2\tfrac{1}{2}(a - A)$$
$$v^2 = D^2 + (d^2 - D^2)\sin^2\tfrac{1}{2}(a + A)$$

In *uniaxal crystals*, when the *two* axes are reduced to *one*, we have A=a, so that

$$V^2 = D^2$$
$$v^2 = D^2 + (d^2 - D^2)\sin^2 A,$$

that is, the ordinary velocity is constant in all directions and equal to D, and, as the second equation indicates, the extraordinary velocity v depends on the angle A, which the extraordinary ray makes with the axis.

When this ray is in the section perpendicular to the axis, we have A=90°, and sin.^{2} A=1, hence V′=d.

When the ray is parallel to the axis A=0°, and sin.^{2} A=0, whence v=D, so that in this direction only the extraordinary becomes equal to the ordinary velocity.

In *biaxal crystals*, when the ray is in the section perpendicular to CD, fig. 129, it is evident that it always forms equal angles with the axes Pp, P′p'. Hence A=a, and sin.$^2\frac{1}{2}$, (a—A)=0, consequently $V^2=D^2$, or V=D. In this way D is the expression of the velocity in this case, and it is on this account that the term *ordinary velocity* is applied to all those which are given by the different values of V.

When the ray on the contrary, is in the section perpendicular to AB, the sum of the angles A and a is always equal to two right angles, and sin. $\frac{1}{2}(A + a)=1$, whence it follows that $V^2=d^2$, and V=d, and it is on this account that the term *extraordinary velocity* is applied to all those that are given by the values of v.

When d is greater than D, the *minimum* of the ordinary velocity takes place when a=A, or when V=D, and the *maximum* takes place when a—A is the greatest possible, which happens in the plane of the axes APCBDP′. The *minimum* becomes the *maximum*, and *vice versa* when D is greater than d. The *maximum* and *minimum* for the extraordinary ray take place also, when v=d, and consequently for the case when the ray is in the plane of the axes, but they in like manner change their part when d is greater or less than D.

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In every case the difference of the squares of the velocities is expressed by the formula

$$v^2 - V^2 = (d^2 - D^2) \sin.\ a.\ \sin.\ A.$$

That is to say, the two ordinary and extraordinary rays having a common direction, the difference of the squares of their velocities are proportional to the product of the sines of the angles which each of them makes with the two axes. "This remark, adds M. Pouillet, had been made by Sir David Brewster and M. Biot before Fresnel had pointed out the simple law which embraces the phenomena in all its extent."

List of the primitive forms of Crystals that have two axes of double refraction.

Crystals with two axes.

From a great number of experiments, Sir David Brewster found that the property of possessing *two* axes of double refraction belonged to all the crystals that are included in the *prismatic system* of Mohs, or which have the following primitive forms of Hauy:—

A right prism,	Base a rectangle.
.....	Base a rhomb.
.....	Base an oblique parallelogram.
Oblique prism	Base a rectangle.
.....	Base a rhomb.
.....	Base an oblique parallelogram.
Octohedron	Base a rectangle.
.....	Base a rhomb.

In these solids there is no single line or axis of symmetry.

The following table, which we could have enlarged considerably, contains most of the crystals with two axes, whose primitive forms have been determined by crystallographers:—

1. *List of Crystals of known Primitive Forms, and having* Two *Axes of Double Refraction.*

1. *Right Quadrangular Prism—Base a Rectangle.*

	Position of Principal Axis.	*Position of Second Axis.*
Cymophane, *Young.*	Axis of right prism.	Perp. to the sides.
Peridot, ditto.	Perp. to axis.	Axis of right prism.
Prehnite, ditto.		
Stilbite, ditto.	Parallel to longest side of prism, or perp. to best cleavage planes.	Axis of right prism, or perp. to longest faces.
Comptonite, *Brooke.*	Perp. to axis of right prism.	Axis of that prism, or other axis.
Thomsonite, ditto.	Perp. to axis of prism.	Axis of the prism.
Anhydrite, *Bournon.*	Axis of right prism.	Perp. to sides of prism
Tartrate of potash, ditto.	Perp. to the flat rhomb. faces.	Parallel to a side of rhomb. prism.
Staurotide, *Hauy.*		
Datholite, do.		
Mica, do.	Axis of right prism.	Greater diagonal of its rhomb. base.
Talc, do.	Axis of right prism.	Diagonal of its rhomb base.
Spodumene, do.	Axis of prism.	In plane of laminæ.
Sulphate of barytes, ditto.	Short diagonal of rhomb. base.	Long diagonal, or axis of prism.
Sulphate of strontian, do.	Axis of the prism.	Perp. to axis of prism.
Sulphate of soda, *Bournon.*		
Citric acid, do.		
Tartrate of potash and soda, do.		
Chromate of lead, do.		
Stilbite, *Brooke.*	Perp. to laminæ.	In plane of laminæ.
Mesotype of Auvergne, do.	Axis of prism.	Perpendicular to axis.

[1] *Elémens de Physique Expérim.* liv. viii. cap. 1.

Double Refraction

3. *Right Quadrangular Prism—Base an Oblique Parallelogram.*

Names of Minerals.	*Position of Principal Axis.*	*Position of Second Axis.*
Needlestone of Faroe,	Axis of prism.	Perpendicular to axis.
do.		
Sulphate of lime, *Hauy.*	In plane of the laminæ.	Axis of prism.
Epidote, do.	In base of prism.	Axis of prism.
Axinite, do.		
Heulandite, *Brooke.*		
Brewsterite, do.		
Sulphato-carb. of lead, do.	Perp. to laminæ.	In plane of laminæ.
Acetate of strontian.		

4. *Oblique Quadrangular Prism—Base a Rectangle.*

Borax, *Hauy.*
Euclase, do.

5. *Oblique Quadrangular Prism—Base a Rhomb.*

Diopside, *Hauy.*	Perpendicular to sides of the prism.	Axis of prism, or other axis.
Euclase, do.		
Augite, do.		
Glauberite.		
Grammatite.		
Sulphate of iron, *Wollaston.*		
Super-sulphate of potash, *Bournon.*	Perp. to axis of prism.	Axis of prism.
Acetate of copper, do.	Perp. to axis of prism.	Axis of prism.
Tartaric acid, do.	Axis of prism.	Perpendic. to faces.
Oxalic acid, do.		
Sugar, do.		
Hydrate of strontian.		
Bitartrate of potash.		
Sulphate of soda.		

6. *Oblique Quadrangular Prism—Base an oblique Parallelogram.*

Feldspar, *Hauy.*
Kyanite, do.
Sulphate of copper, do.

7. *Octohedron with a Rectangular Base.*

Nitrate of potash.	Axis of octohedron.	Perp. to sides of base
Arragonite.	Axis of prism or perpendicular to axis of octohedron.	Perp. to sides of base
Carbonate of lead.	In plane of base of two pyramids.	Axis of the octohedron.
Sulphate of lead.	Axis octohedron.	Perp. to sides of rect. base.
Topaz.		
Muriate of copper.	Long diagonal of rhomb. base.	Short diagonal of the rhomb. base.

8. *Octohedron with a Rhombic Base.*

Sulphur, *Hauy.*		
Sphene, do.		
Carbonate of soda, do.	Diagonal of base through *o* of Hauy, Pl. xxxix.	Axis of octohedron or other axis.

9. *Minerals belonging to the Prismatic System of Mohs, and having* TWO *axes, but not included in any of the above divisions of Hauy.*

Sulphate of magnesia, *Mohs.*	Cleavable diagonal of square base.	Perpendicular to axis, or the other diagonal.
Sulphate of manganese.		
Sulphate of zinc.	Axis of rhomboidal prism.	Short diagonal of rhomboidal base.
Sulphate of ammonia.	Axis of hexahed. prism.	Perp. to axis.
Sulphate of cobalt.		
Carbonate of strontian, do.	Axis of prism.	Perp. to axis.
Carbonate of barytes, do.	Axis of prism.	Perp. to axis.
Diallage.	Perp. to plates.	Plane of plates.
Molybdate of ammonia.		

Names of Minerals.	*Position of Principal Axis.*	*Position of Second Axis.*
Muriate of barytes.		
Realgar.		
Orpiment.	In plane of laminæ.	Perp. to laminæ.
Lepidolite.	Perp. to laminæ.	Plane of laminæ.
Mesotype.	Axis of prism.	Perp. to axis.
Mesolite.	Ditto.	Ditto.
Serpentine.		
Natrolite.		
Sulphato-bi-carbonate of lead.	Axes of acute rhomb.	In plane of laminæ.
Phosphate of iron.	In plane of laminæ.	Perp. to laminæ.
Harmotome, Petalite, Chabasie.		

10. *Crystals, whose primitive form has not been determined, but which have been found to have two axes, and which must belong to the Prismatic System of Mohs.*

Iolite.	Axis of prism.	Perp. to axis of prism.
Indurated talc.	Perp. to plates.	In plane of laminæ.
Carbonate of potash.	Plane of axis perpendicular to the flat tables.	In plane of tables.
Carbonate of copper.		
Sulphate of ammonia and magnesia.	Shorter diagonal of the rhomboidal base.	Axis of hexagonal prism, or long diag. of rhomb. base.
Sulphate of soda and magnesia.		
Sulphate of nickel.	Short diagonal of the rhomboidal base.	Axis of prism, or other axis.
Oxy-nitrate of silver.	Perp. to rhomb plates	Long diagonal of rhomboidal plates.
Nitrate of ammonia.		
..... of lime.		
..... of strontian, with water of crystallization.		
..... of copper.		
..... of zinc.		
..... of mercury.		
..... of bismuth.		
Nitrate of lead, certain specimens.	Mr. Herschel, *Edin. Ph. Jour.* vol. ii. p. 184.	
Muriate of mercury.		
..... of magnesia.		
Acetate of lead.	Perp. to broad sides of prism.	Axis of prism, or other axis.
..... of zinc.	In plane of hexag. plates.	Perpendicular to hexag. plates.
..... soda.		
..... barytes.		
Phosphate of soda.		
Oxalate of ammonia.	Perp. to axis of prism.	Axis of prism.
Hyper-oxymuriate of potash.	Perpendic. to rhomb. plates.	Plane of axis in that diag.
Super-oxalate of potash.		
Super-chromate of potash.		
Crystallized Cheltenham salts.	Axis of prism.	Perp. to axis.
Murio-sulphate of magnesia and iron.	Cleavable diagonal of its square base.	Axis of prism, or other diag.
Benzoate of ammonia.	Perp. to laminæ.	In plane of do.
Benzoic acid.	Perp. to plates.	In plane of plates.
Chromic acid.		
Spermaceti.	Perp. to plates.	In plane of plates.
Boracic acid.	Perp. to hexag. plates.	In plane of plates.
Succinic acid.	Perp. to faces of flat prism.	In plane of these faces.
Super-tartrate of potash.	Perpendicular to axis of prism.	Axis of prism.
Tartrate of potash and antimony.	Perpendicular to axis of prism.	Axis of prism.
Camphor.		
Hydrate of barytes.	Perp. to flat plates.	In ane of plates.
Prussiate of potash.	Perp. to rect. laminæ.	In plane of laminæ.
Mother-of-pearl.	Perp. to laminæ.	In plane of laminæ.
Carbonate of ammonia.	Short diag. of rhomb, and perp. to best cleavage.	Axis of prism, or long diag.
Hyposulphite of lime.	Sir John Herschel, *Edin. Phil. Jour.* vol. i. p. 15.	
..... of barytes.	Sir John Herschel.	

Double Refraction.

Polarisation.

Sect. III.—*On Crystals with three Axes of Double Refraction.*

Crystals with three axes.

Having determined the primitive form to which those crystals belong which have *one* and *two* axes of double refraction, Sir David Brewster found that all those crystals which have no resultant axes, or, properly speaking, no double refraction, belonged to that class of primitive forms which have three rectangular axes of form, namely, the *cube*, the *regular octahedron*, and the *rhomboidal dodecahedron*, or to the *tessular* system of Mohs. Since, however, every real axis of double refraction, coincides with a prominent line in the primitive form of the crystal, he conceived that those crystals which had no apparent double refraction had actually *three equal rectangular axes*, the effect of which was to compensate each other at every point of the crystal, or, in other words, to have an infinite number of resultant axes.

In confirmation of these views, our author found various indications of positive and negative doubly refracting structures in *alum*, *diamond*, &c., as if these equal axes had not exactly compensated each other, either from the three not being perfectly equal, or from their not being placed accurately at right angles to each other.

The following is a list, which might be considerably extended, of the primitive forms of the crystals that have no double refraction.

Primitive form a cube.—Muriate of soda, muriate of potash, muriate of silver.

Primitive form an octahedron.—Diamond, fluor spar, muriate of ammonia, pleonaste, nitrate of lead, sulphate of alumina, soda, alum, ruby copper, spinelle, nitrate of strontian octahedral, nitrate of lead, nitrate of barytes, sulphate of ammonia and chromium, sulphate of ammonia and iron, sulphate of alumina and ammonia.

Primitive form a rhomboidal dodecahedron.—Garnet, blende, sodalite, essonite, helvin, lazulite.

There are some crystals, such as *arseniate of iron*, *amphigene*, *analcime*, *boracite*, *aplome*, all of which have double refraction, and therefore cannot belong to the tessular system.

Sect. IV.—*On Crystals with Planes of Double Refraction.*

In all the crystals to which we have hitherto referred, the double refraction is related to one or more axes; but Sir David Brewster has found, that in *analcime*, a mineral ranked in the tessular system, there are several planes or sections of the crystal in which there is no double refraction, the double refraction increasing with the distance from these planes, according to a law which will be afterwards mentioned. When the ray is incident in any direction that does not lie in one of these planes, it is separated into two images by double refraction. This is the only substance which is known to possess this remarkable property.

PART VII. ON THE POLARISATION OF LIGHT.

Polarisation of light.

The light emitted from the sun, from a candle, or from any self-luminous body, before it has suffered reflection from, or refraction by, any body, is called *common light*. If we allow a beam of such light to fall upon any refracting or reflecting body, whether transparent or metallic, or to pass by any diffracting body, it will suffer precisely the same changes, whether its upper, its under, its right or its left side, or any other side of the beam, is turned towards the refracting, reflecting, or diffracting body. Hence it follows, that this beam of light has the same properties in all its sides.

Now this is not true of all light. If the preceding beam of common light is reflected at a particular angle, from transparent bodies, or passes obliquely through a number of refracting surfaces, or is transmitted through certain crystals, or suffers total reflexion from the second surfaces of transparent bodies, or from the surface of metals;—in all these cases it has suffered such a change, that it no longer has the same properties in all its sides, but, on the contrary, exhibits distinct and remarkable properties in its different sides, or, what is the same thing, has *polarity*. This beam of common light is therefore said to be *polarised*. The different kinds of polarisation which may thus be impressed upon common light are three, viz. *plane polarisation*, *circular polarisation*, and *elliptical polarisation*; or the whole of these three kinds of polarisation may be included in the general name of *elliptical polarisation*, which becomes *circular* when the two axes of the ellipsis are equal, and *rectilineal* or *plane* when the minor axis of the ellipse is infinitely small. We shall now proceed to explain the phenomena of these three kinds of polarisation, in their order.

Polarisation.

CHAP. I.—ON PLANE POLARISATION.

Plane polarisation.

There are four ways by which common light may be *plane polarised*.

1. By double refraction.
2. By one reflection from transparent bodies.
3. By several refractions through transparent surfaces.
4. By the absorption or dispersion of part of the light.

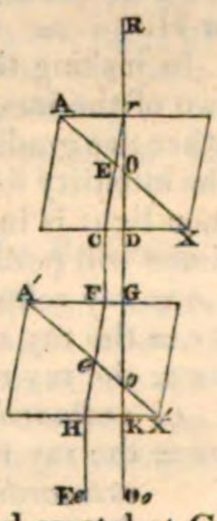
These various processes exhibit many interesting phenomena and laws, which we shall proceed to explain.

Sect. I.—*On the Polarisation of Light by Double Refraction.*

Polarisation by double refraction.

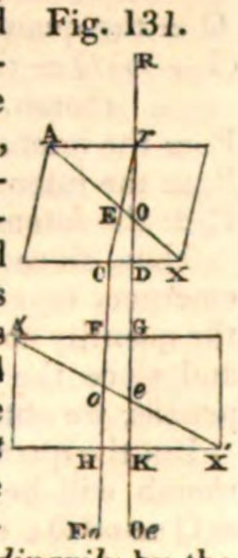
The polarisation of light by the double refraction of Iceland spar was discovered by Huygens. Upon examining the two pencils O *o*, E *e*, fig. 118, formed by double refraction, he found that they had different properties on different sides, and that both of them differed from common light as well as from one another. He discovered this difference in the following manner.

Fig. 130.



Having taken two pieces of Iceland spar, he placed them symmetrically, as in fig. 130, with all the faces of the one parallel to all the faces of the other, A *r* X, A′ G X′ being the principal sections of two rhombs. A ray of common light R *r*, incident upon the first crystal at *r*, is divided into two pencils *r* C, *r* D, O being the ordinary and E the extraordinary ray, as formerly explained. Now the ordinary ray D G, falling upon the second crystal at G, and the extraordinary one CF at F, should have been each subdivided, by double refraction, into two pencils, by that crystal; but they are not, the *ordinary* ray D G being *only* refracted *ordinarily*, and the *extraordinary* ray C F *only extraordinarily*, as seen in the figure, where these rays F H, GK, emerge singly at H and K, the one an *ordinary* and the other an *extraordinary* ray. If the upper rhomb remains fixed while the under one is turned round 90°, so that its principal section is perpendicular to that of the upper one, as shown in fig. 131, the same phenomena will take place, with this difference only, that the ray D G refracted *ordinarily* by the *first* crystal, is refracted *extraordinarily* by the *second*, and the ray C F, refracted *extraordinarily* by the *first* crystal, is refracted *ordinarily* by the *second*.

Fig. 131.



Hence it is manifest, that the ray of common light R *r*, and the two doubly refracted pencils C F, D G, have all

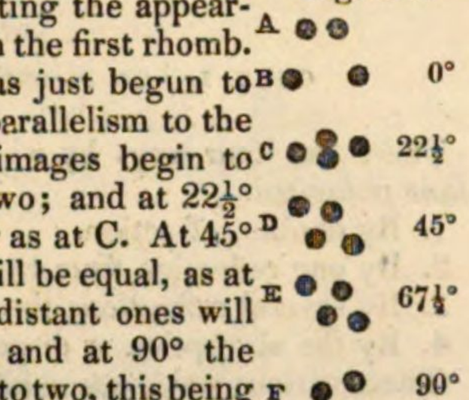
Polarisation.

different properties. For if R *r* were to fall upon the second rhomb, it would be divided into two pencils; whereas C F and D G refuse to be so divided, and are each refracted in different ways by the second crystal.

Now, in *every other position* of the four rhombs, between the two where their principal sections are *parallel*, or *perpendicular* to one another, the two pencils C F, D G are divided into two pencils, and *four* separate pencils emerge from the second rhomb.

In order to understand the phenomena presented by these *four* pencils, when the second rhomb performs a complete revolution behind the first one, let us suppose that the lower rhomb begins to revolve from the position in fig. 129, which we shall call 0° of azimuth, and in which case we shall have two horizontal pencils H E, K O, fig. 131, whose sections[1] are shown in the annexed figure at B, opposite 0°; A representing the appearance of the aperture through the first rhomb. When the second rhomb has just begun to move out of its position of parallelism to the first, two extremely faint images begin to appear between the other two; and at 22½° of azimuth they will appear as at C. At 45° of azimuth their intensity will be equal, as at D; at 67½° the two most distant ones will have become the faintest; and at 90° the four images will be reduced to two, this being the position shown in fig. 130. By continuing to turn the second rhomb, other two faint images start up, which at 112½° appear as at G; at 135° the four images are equally bright, as at H; at 157½° the two outermost are the faintest; and at 180° they all coalesce into one bright image, as at K, having twice the brightness of either of those at A or F, and *four* times the brightness of any one of the four at D or H.

Fig. 132.



Malus's law of intensity.

In making the preceding experiment, it will be seen that two of the images gradually increase in brightness, while other two gradually diminish. Malus investigated the law of the intensity for these images, both when the pencil of common light is incident perpendicularly and obliquely. Our limits will permit us to give only the simplest case, making

o = ray refracted *ordinarily* by the *first* rhomb.
e = the ray refracted *extraordinarily* by the *first* rhomb.
oo = the ray refracted *ordinarily* by the *first* rhomb, and *ordinarily* by the *second*.
oe = the ray refracted *ordinarily* by the *first* rhomb, and *extraordinarily* by the *second*.
ee = the ray refracted *extraordinarily* by the *first* rhomb, and *extraordinarily* by the *second*.
eo = the ray refracted *extraordinarily* by the *first* rhomb, and *ordinarily* by the *second*.
Q = the quantity of light contained in the incident ray.
$(1-m)\,Q$ = the quantity of light absorbed by the first rhomb.
P = the intensity of any of the pencils.
P_o = the intensity of the *ordinary* emergent ray.
P_e = the intensity of the *extraordinary* emergent ray.

Then, since the quantity of light contained in the two emergent rays is equal to the incident light diminished by the quantity absorbed, we shall have $Q-(1-m)\,Q = m\,Q$; and since the light is equally divided between the two pencils, we obtain $P_o = \frac{1}{2} m\,Q$, and $P_e = \frac{1}{2} m\,Q$.

But the quantity of light $m\,Q$ which falls upon the second rhomb will be reduced by absorption to $m\,Q-(1-m)\,m\,Q = m^2\,Q$; consequently, if a is the angle formed by the principal sections of the two rhombs, we shall have

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First pencil, $P_{oo} = \frac{1}{2}(m^2\,Q\cos.^2 a)$.
Third pencil, $P_{ee} = \frac{1}{2}(m^2\,Q\cos.^2 a)$.
Second pencil, $P_{oe} = \frac{1}{2}(m^2\,Q\sin.^2 a)$.
Fourth pencil, $P_{eo} = \frac{1}{2}(m^2\,Q\sin.^2 a)$.

When the principal sections of the two rhombs are parallel, then $a = 0$, and $\sin.^2 a = 0$, consequently $P_{oe} = 0$, and $P_{eo} = 0$; that is, *the third and fourth pencils will disappear*.

When, on the contrary, the principal sections are at right angles to one another, $a = 90°$, and $\cos.^2 a = 0$, consequently $P_{oo} = 0$, and $P_{ee} = 0$; that is, *the first and second pencils will disappear*.

When the incident ray is not perpendicular to the surface of the first rhomb, the intensities of the pencils are functions of the angles of incidence and the angle which the ray forms with the principal sections.

All the phenomena above described may be produced by combining any two *positive* and any two *negative* crystals; but if a positive is combined with a negative crystal, the same effects will be produced when the principal sections are at right angles to each other, as when they are parallel in the other cases.

The difference between common and polarised light, as evinced by the phenomena of double refraction, is, that the former may always be divided into two pencils by a doubly-refracting crystal, whereas the latter is not capable of being so divided under certain circumstances.

As the four polarised pencils, when united, as at K, fig. 132, produce a pencil of common light, or rather a pencil which cannot be distinguished from common light, it is highly probable that the Iceland spar, in converting common into polarised light, by refracting it into two pencils, has not communicated to it any new property, but has merely separated it into its two elements, just as a prism separates a pencil of white light into its seven elementary colours by refraction, these colours again forming white light by their reunion.

Sect. II.—*On the Polarisation of Light by Reflection.*

Polarisation by reflection.

We have already stated, in the history of Optics, the manner in which the celebrated French philosopher Malus discovered the polarisation of light by reflection. Upon repeating his experiments with a variety of opaque and transparent bodies, not metallic, such as glass, water, &c. he found that, *when light was reflected at a particular angle from such bodies, it was polarised exactly like one of the pencils formed by double refraction*, the pencil polarised by reflection having all its properties identically the same with that of the doubly-refracting crystal. Like the latter, it was no longer capable of being divided into *two* pencils by a rhomb of Iceland spar; and as, in the polarisation of light by the double refraction of one crystal, that property depends on the angle formed between the principal sections of the two crystals, as shown in figs. 130 and 131, so, in the present case, the polarisation depends on the angle formed between *the plane of reflection* and that of the principal section of the crystal which polarises the light. In all such phenomena, indeed, as Malus remarks, the *plane of reflection* replaces the plane of the principal section of the crystal.

If we receive the ray polarised by reflection from water at an angle of 52° 45′, upon any crystal having double refraction, it will not be divided into two pencils when the plane of reflection is parallel to the principal section, as if it had been a pencil of common light; but it will be refracted entirely, according to the ordinary law, as if the crystal had lost the power of double refraction. If, on the other

[1] If we place a circular aperture, the size of the little dark circles in fig. 132, at *r*, the images will have that form.

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hand, the principal section of the crystal is perpendicular to the plane of reflection, the reflected ray will be refracted wholly, according to the law of extraordinary refraction. In all intermediate positions it will be divided into two rays, according to the same law, and in the same proportions, as if it had acquired its new character by the influence of double refraction.

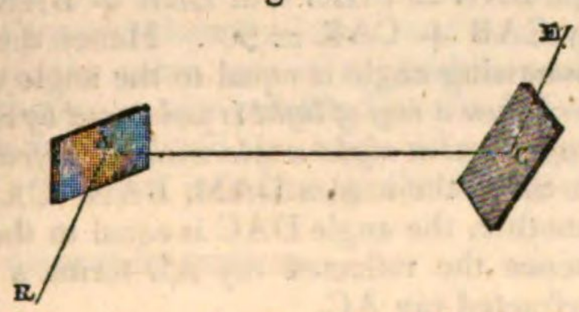
In order to analyse this phenomenon completely, he placed the principal section of a crystal vertically; and after having divided a ray into two by it, he made these two rays fall on the surface of *water*, at an angle of 52° 45′. The ordinary ray was partially reflected, like common light, but *the extraordinary ray penetrated the water wholly, and not a single particle of it was reflected.* When the principal section of the crystal was, on the contrary, perpendicular to the plane of incidence, the *extraordinary* ray was partially reflected, and *the ordinary ray was wholly refracted.*

Malus found the phenomena to be the same for all other transparent bodies, whether solid or fluid; but the angle at which light experienced this modification was in general greater in bodies which refracted light most. Below and above this limit the rays were more or less modified.

This property of reflected light takes place at a different angle for pencils reflected at the *second surfaces* of bodies, and the sine of the angle at the first surface is to the sine of the angle at the second, as the sine of incidence is to the sine of refraction. Hence, in parallel plates, either of glass or other bodies, the two pencils which are reflected in the same directions from both surfaces have equally received this new property, and the light which has received it is said to have been *polarised by reflection.*[1] M. Malus found the same property in black bodies, such as *black marble, ebony,* &c.[2]

Malus next proceeded to study the phenomena when the light R, polarised by one plate of glass A, was reflected from a second plate C, fig. 133, the ray RA being incident on the first plate, and the polarised ray AC on the second plate at an angle of 56°, the polarising angle of glass. In the case shown in the figure, the plane of reflection ACE, in the plate C, is at right angles to the plane of reflection RAC from the first plate, and in this case the reflected pencil CE wholly vanished, all the reflected and polarised light AC having penetrated the glass at C. If we now turn round the plate C from this point, or *zero*, into different azimuths, so that it is always equally inclined to the polarised ray, a small portion of the ray AC will be reflected from C, and this portion will increase till it becomes a maximum, when the plane ACE is parallel to RAC, or in the azimuth of 90°. By continuing to turn the plate C, the reflected ray CE will gradually diminish, and when C has reached the azimuth of 180° its plane of reflection will be perpendicular to that of A, and the reflected ray CE will wholly disappear. In advancing from 180° to 270°, CE will again reach its maximum, and at 360°, when it has returned to its position, as in the figure, it will again return to its minimum.

Fig. 133.



While the reflected pencil CE passes from its *minimum* intensity at 0° and 180°, to its maximum at 90° and 270°, Malus supposes the intensity to vary as the square of the cosine of the angle of azimuth, or of any even power of the cosine. Calling a the angle of azimuth which the plane of the second reflection makes with a plane perpendicular to RAC, I the maximum intensity of the reflected pencil, and P the intensity corresponding to any azimuth a, then $P = I \cos.^2 a$. If we make a equal to 0°, 90°, 180°, and 270°, we shall have, when $a = 0°$, $\cos. a = 1$, $\cos.^2 a = 1$, $\cos.^4 a = 1$, and consequently P=I, or the reflected pencil is a maximum. When $a = 90°$, $\cos. a = 0$, $\cos.^2 a = 0$, $\cos.^4 a = 0$, and $F = 0$, that is, the reflected pencil wholly disappears.

It is obvious, from the arrangement of glasses in fig. 132, that, if the light R proceeds from the sky, an observer with his eye placed at E will see a black spot in the part of the sky from which the light R comes, as the whole of the light penetrates the plate C. If the light R comes from a house, the house will disappear if it is at a considerable distance; and by turning round C, the house will have its greatest brightness when the two planes of reflection are parallel. If, in the position when the house was invisible, we breathe upon the plate C, the house will suddenly become visible, and will again disappear when the breath has evaporated. If we now place the plate C at an angle of 52° 45′ to the ray AC, the house will be seen; but if we again breathe upon CC, the house will disappear. The cause of these phenomena is, that by breathing upon C we make the reflecting surface an aqueous one, which refuses to reflect light at an angle of 52° 45′, but reflects it at 56°.

If we place beside each other two sets of reflectors arranged in the manner shown in the figure, C being inclined in the one set 56° to A, and in the other set 52° 45′, and the plates C, C being near each other, we may, by breathing upon each at the same time, exhibit the paradoxical phenomenon of reviving and extinguishing a luminous image by the same breath, or we may appear to breathe at the same time light and darkness.[3]

1. *On the Law of the Polarisation of Light by Reflection.*

Law of polarisation by reflection.

After determining the angle at which different bodies polarised light, Malus concluded that "this angle followed neither the order of refractive powers nor that of the dispersive forces, and that it was a property of bodies independent of the other modes of action, which they exercised over light.[4]

Law of the tangents.

In repeating the experiments of Malus, Sir David Brewster measured the polarising angles of a greater number of bodies, but experienced many difficulties in connecting them together by a simple law. In some substances the light was not completely polarised at any angle. In others purple and blue light was left at the polarising angles; and in various specimens of glass, different parts of the same surface gave different polarising angles. The first of these phenomena he ascribed to the circumstance that the differently coloured rays of white light were polarised at different angles; and the second he found to arise from changes that had taken place on the surfaces of glass by partial decomposition, owing to the action of the atmosphere. By rejecting those substances where the action of the surface was thus masked or disturbed, he was led to the following general law, that *the index of refraction of any body is the tangent of its angle of polarisation.*

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[1] *Théorie de la Double Refraction*, sect. 48.

[2] *Ibid.* sect. 50.

[3] This experiment was described by Sir David Brewster, in the Edin. Phil. Journal, vol. vii. p. 146. See also his Letters on Natural Magic, p. 125.

[4] *Bull. de Sciences de la Soc. Philos.* Juin 1811, No. 45, tom. ii. p. 294

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The following were the experiments on which this law was founded :—

Names of the Bodies.	Observed Polarising Angles.	Calculated Polarising Angles.
Air	45° or 47°	45° 0′ 32″
Water	52 59[1]	53 11
Fluor spar	54 50	55 9
Obsidian	56 3	56 6
Sulphate of lime	56 28	56 45
Rock crystal	57 22	56 58
Sulphate of barytes	58 29	58 33
Opal-coloured glass	58 1	58 33
Topaz	58 40	58 34
Mother-of-pearl	58 47	58 50
Iceland spar	58 23	58 51
Orange-coloured glass	59 12	59 28
Spinelle ruby	50 6	60 25
Zircon	63 8	63 0
Glass of antimony	64 45	64 30
Sulphur	64 10	63 45
Diamond	68 2	68 1
Chromate of lead	67 42	68 3

Upon repeating these experiments with homogeneous light, our author also found that the angle of polarisation varied with the refrangibility of the light, and that the tangent of the polarising angle was equal to the index of refraction of the light employed.

Hence we are able to explain why, at the maximum polarising angle, a portion of unpolarised light must always remain, and why this portion increases with the refractive and dispersive power of the body. This will be understood from the following table :—

Water.

Index of Refraction.	Colour of the Light.	Polarising Angle.	Variation.
1·330	Red	53° 4′	
1·336	Green, or mean ray	53 11	...0° 15′
1·342	Violet	53 19	

Plate Glass.

1.515	Red	56 34	
1·525	Green	56 45	...0 21
1·535	Violet	56 55	

Oil of Cassia.

1·597	Red	57 57	
1·642	Green	58 39	...1 24
1·687	Violet	59 21	

Now it is obvious, that when the *green* or mean, or most luminous ray, is polarised, and therefore vanishes, neither the red nor the violet has wholly vanished, and consequently a portion of unpolarised light, composed of a portion of these two colours, will still be visible. In oil of cassia the quantity of light is considerable, and is of a fine *blue* colour.

Dr. A. Seebeck's experiments.

So recently as 1830, Dr. A. Seebeck of Berlin has published a series of very accurate and valuable experiments made by an instrument constructed for the purpose, which, if any doubts had existed about the accuracy of the preceding law, were sufficient to remove them. Dr. Seebeck's principal object seems to have been to obtain accurate measures of the polarising angle of different glasses, when the surfaces were newly polished, in order to reconcile the law to that class of bodies in which the deviations had been found to arise from some chemical or mechanical changes produced upon their surface. The following table contains Dr. Seebeck's experiments :—

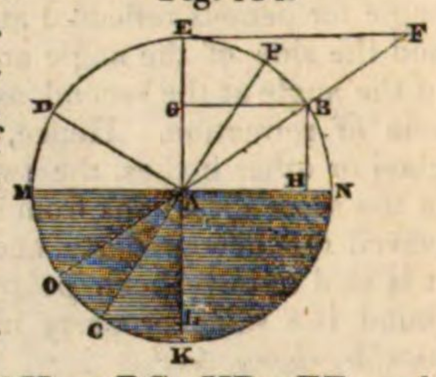
Names of the Bodies.	Index of Refraction.	Polarising Angles. Observed.	Polarising Angles. Calculated.
Fluor spar, colourless	1·4341	55° 6′·7	55° 6′·7
——— greenish blue	1·4343	55 3·8	55 7·0
Common opal	1·4516	55 29·3	55 26·3
Plate-glass, English, colourless	1·5130	56 36·0	56 32·2
——— colourless	1·5266	56 45·5	56 46·4
Crown-glass, English	1·5321	56 50·2	56 52·0
——— ditto	1·5523	57 12·6	57 12·6
Flint-glass, English	1·5783	57 41·0	57 38·5
——— ditto	1·6206	58 16·6	58 19·4
Pyrope	1·8131	61 4·0	61 7·7
Yellow blende	2·3692	67 8·2	67 7·0

Upon examining the polarising angles of different specimens of glass at different periods, after the surfaces were polished, Dr. Seebeck confirmed the explanation given by Sir David Brewster, of the variations in their polarising angles.[2]

When a pencil of light is polarised by reflection, the sum of the angles of incidence and refraction is a right angle.

Let MN, fig. 134, be the reflecting surface, and BA a ray of light polarised by reflection in the direction AD, and let AC be the refracted ray. Then, since EF, the tangent of the polarising angle BAE, is equal to m, or the index of refraction, we have, by the law of the sines, $CL = \frac{BG}{m} = \frac{BG}{EF}$. But from the similar triangles ABH, AEF, we have AH, or BG : HB :: EF : rad., and $HB = \frac{BG}{EF}$, consequently CL = HB, and the angle BAN = CAK. But EAB + BAN = 90°, consequently EAB + CAK = 90°. Hence the complement of the polarising angle is equal to the angle of refraction.

Fig. 134.



When a ray of light is polarised by reflection, the reflected ray forms a right angle with the refracted ray.

Since the angles DAM, BAN, CAK, are equal to one another, the angle DAC is equal to the right angle MAK ; hence the reflected ray AD forms a right angle with the refracted ray AC.

When a pencil of light is incident on the second surface of transparent bodies, at an angle whose cotangent is equal to the index of refraction, the reflected portion will be either wholly polarised, or the quantity of polarised light which it contains will be a maximum.

As the images formed by the first and second surfaces of a transparent plate are simultaneously polarised, this proposition is established by the experimental results in the preceding table.

The angle of polarisation at the second surface of transparent bodies is the complement of the angle of polarisation at the first surface.

As the angle of incidence at the second surface is equal to the angle of refraction at the first surface, and as this latter angle is equal to the complement of the angle of polarisation, it follows that the two polarising angles are complementary to each other.

When a ray of light is polarised by reflection from the second surface of transparent bodies, the reflected ray will form a right angle with the refracted ray.

[1] Mean of four observations by Malus, Biot, Arago, and Brewster.

[2] See Poggendorf's *Annalen*, 1830, No. 9, p. 27 ; or Edin. Journ. of Science, N. S. vol. v. p. 99.

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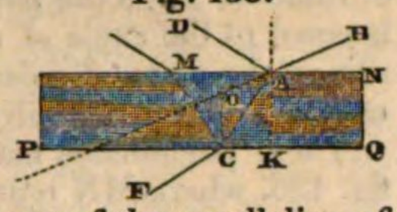
Let AB, fig. 135, be a ray incident at the first surface MN, AD the ray polarised at that surface, AC the ray incident at the second surface PQ, and CM the ray polarised at that surface; then, if CF be the refracted ray, the angle MCF is a right angle. But DAC is a right angle, and on account of the parallelism of MN, PC, and BA, CF, the angle FCP is equal to DAM; but MCP is equal to MAC, hence the whole MCF is equal to the whole DAC, or a right angle.

Fig. 135.



Cor. 1. The ray CM, reflected by the second surface, is at right angles to the ray AB incident on the first surface.

Cor. 2. The internal reflected ray CM forms with the external reflected ray AD, an angle equal to the angle of deviation CAO.

Cor. 3. The ray CF, emerging from the second surface, forms, with the first reflected ray AD, an angle equal to the complement of the angle of deviation.

When a pencil of light is incident upon the separating surface of two media having different indices of refraction m, m′, *it will be polarised at an angle whose tangent is equal to the quotient of the greater index of refraction divided by the lesser, or* $\frac{m}{m'}$, *if* m *exceeds* m′.

This truth is a necessary consequence of the general law, and was also deduced from direct experiment. If the uppermost of the two media is a parallel plate, such as water lying upon a horizontal surface, &c. the separating surface of the two media cannot, at any angle of incidence upon the first surface, completely polarise the incident light, unless the sine of the angle whose tangent is $\frac{m}{m'}$, is, when multiplied by m, less than unity. Thus, in the case of water and glass, the polarising angle is 68° 47′, but no ray incident upon the water, even at 90°, can fall at such an oblique incidence upon the glass as 48° 47′. For sin. 48° 47′ × m' (or the angle of refraction at an incidence of 90°), is = 1·0048. When the upper medium has a higher refractive power than the lower, and lies in a parallel plate upon it, the same law is applicable, with this difference, that the ray is now polarised at the *second surface* of the denser medium, and the angle of polarisation is that whose cotangent is equal to the index of refraction $\frac{m}{m'}$, of the separating surfaces.

Partial polarisation.

In the preceding observations, we have considered only the light which is incident at the polarising angle. It becomes interesting to inquire, what is the condition of the light which is incident at angles above and below the polarising angle. Malus, Arago, Biot, Fresnel, and other distinguished philosophers, considered the light thus reflected as consisting of two pencils, one of which preserved its state of common light, while the other pencil was polarised in the plane of incidence. In the year 1815, however, Sir David Brewster was led, by direct experiments, to a very different opinion, namely, that the pencil of light which was supposed to have preserved its character of common light had *suffered a physical change in its condition, or had acquired in various degrees a character approaching to complete polarisation.* He found, for example, that a pencil of light reflected from glass, either at 62° 30′ or 50° 20′, was so far polarised, that it was wholly polarised by a second reflection at either of these angles; whereas, had the unpolarised part been common light, it could not have been polarised at any angle but 56° 45′. In like manner, he found that *three* reflections at 65° 33′ or 46° 30′, and *four* at 67° 33′ or 43° 51′, polarised the whole pencil; and in general he found *that a ray of light partly polarised by reflection at any angle, will be more and more polarised by every successive reflection in the same plane till its polarisation is complete, whether the reflections are made at angles all above or all below the polarising angle.* Polarisation.

These views were not acceded to by philosophers, though founded on direct experiment; and, so late as 1825, Sir John Herschel, in discussing the question, gives his decision in favour of the opinion held by the French philosophers.[1] Sir David Brewster was therefore induced to repeat and extend his experiments, and succeeded in establishing his original view of the subject on an impregnable basis. A brief account of these experiments will form the subject of the next section.

2. *On the Motion of the Plane of Polarisation by Reflection.*

Motion of the plane of polarisation.

MM. Fresnel and Arago, and Sir David Brewster, were engaged about the same time in inquiries upon this subject. If we suppose a pencil of polarised light polarised in a plane inclined 45° to a vertical line, and if we reflect it at different angles from a transparent surface in which the plane of reflection is perpendicular to the horizon, the plane of polarisation will be gradually reduced from 45° to 40°, 35°, 30°, 25°, &c. as we diminish the angle of incidence from 90° till we reach the polarising angle, when the plane of polarisation will be inclined 0°, or will be brought into the plane of reflection. At angles less than the polarising angle the plane continues to turn in the same direction, till at 0° it is again inclined 45° to a vertical plane, or to the plane of reflection, having performed a revolution of 90°, the first 45° during the change of incidence from 90° to 56° 45′, and the other 45° from 56° 45′ to 0°.

M. Fresnel represented these changes by the following law: i being the angle of incidence, i' the angle of refraction, x the primitive inclination of the plane of the polarised ray to the plane of reflection, and φ the inclination to which that plane is brought by reflection.

$$\text{Tan. } \varphi = \text{tan. } x \frac{\text{cos. } (i + i')}{\text{cos. } (i - i')}.$$

When $x = 45°$, tan. $x = 1$, and

$$\text{tan. } \varphi = \frac{\text{cos. } (i + i')}{\text{cos. } (i - i')}.$$

In these formulæ founded on the law of the tangents, $i + i'$ is the supplement of the angle which the reflected ray forms with the refracted ray, while $i - i'$ is the deviation produced by refraction.

The following are the observations with glass and water, with which M. Arago verified the last of these formulæ, in which $x = 45°$.

Glass.

Angles of Incidence.	Inclination of Plane of Polarisation to Plane of Reflection. Observed.	Calculated.	Difference.
24	38° 55′	37° 54′	−1° 1′
39	24 38	24 38	+0 3
49	11 45	10 52	−0 53
60	5 15	5 29	−0 14
70	19 52	20 24	−0 32
80	32 45	33 25	−0 40
85	38 55	39 19	−0 24
87	40 55	41 36	−0 41
88	41 15	42 44	−1 29
89	44 35	43 52	+0 43

[1] Treatise on Light, sect. 866, 867.

Polarisation.

Water.

Angles of Incidence.	Inclination of Plane of Polarisation to Plane of Reflection. Observed.	Calculated.	Difference.
60	10° 20′	10° 51′	—0° 31′
70	25 20	24 48	+0 32
80	36 20	35 49	+0 21
85	40 50	40 32	+0 18

The following observations were made by Sir David Brewster on glass.

Glass.

90°	45° 0′	45° 0′	0° 0′
88	43 4	42 49	+0 35
86	40 43	40 36	+0 7
84	38 47	38 22	+0 25
80	33 13	33 46	—0 33
75	28 45	27 41	+1 4
70	22 6	21 3	+1 3
65	14 40	13 53	+0 47
60	6 10	6 16	—0 6
56	0 0	0 0	0 0
50	9 0	9 0	0 0
45	16 55	16 31	+0 24
40	22 37	23 1	—0 24
30	32 25	33 19	—0 54
20	39 0	40 4	—1 4
10	44 0	43 49	+0 11

Diamond.

90° 0′	45° 0′	45° 0′	0° 0
85 0	34 30	33 56	+0 34
80 0	24 0	23 12	+0 48
75 0	14 30	13 8	+1 22
70 0	4 30	3 54	+0 36
67 43	0 0	0 0	0 0
60 0	12 30	11 41	+0 49
50 0	24 0	23 30	+0 30

Our author also made another series of experiments, which confirms the general formula. As $x = 45°$ in the preceding experiments, he wished to observe the law of variation for φ when x varied from 0° to 90°. He took a crystal of quartz with a fine natural face parallel to the axis, and he found, that at an angle of incidence of 75°, and when x was $= 45°$, the inclination of the plane of polarisation to the plane of reflection was 26° 20′. We have therefore $\frac{\cos.(i+i')}{\cos.(i-i')} = \text{tan. } 26°\ 20'$, and consequently the general formula becomes tan. $\varphi =$ tan. x. tan. 26° 20′, by which the third column in the following table has been calculated.

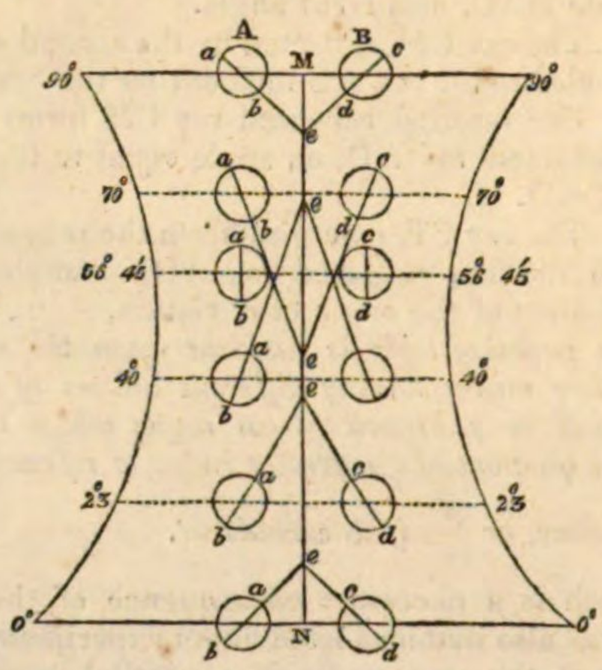
Values of x.	Inclination of Plane of Polarisation. Observed.	Calculated.	Difference.
0	0° 0′	0° 0′	0° 0′
10	4 54	4 29	+0 25
20	10 0	10 16	—0 16
30	15 50	16 2	—0 12
35	20 0	19 12	+0 48
40	23 30	22 40	+0 50
45	26 20	26 27	—0 7
50	30 0	30 40	—0 40
55	35 30	35 23	+0 7
60	40 0	40 45	—0 45
70	53 0	53 49	—0 49
80	70 0	70 29	—0 29
90	90 0	90 0	0 0

It is a curious circumstance, that at an incidence of 45° the deviation produced by refraction, or $i - i'$, is, *in every substance*, the complement of the angle of refraction i' to 45°; and in the action of all substances in turning round the planes of polarisation, at an incidence of 45°, the angle of rotation, when the plane of the polarised ray is $\pm$ 45°, is equal to the angle of refraction, while the new inclination of the plane of polarisation to the plane of reflection, or φ, is equal to the deviation $i - i'$.

Polarisation.

These phenomena may be represented to the eye as in fig. 136, where MN represents the plane of incidence divided into ninety equal parts, and *ab*, *ab*, *ab* the planes of

Fig. 136.



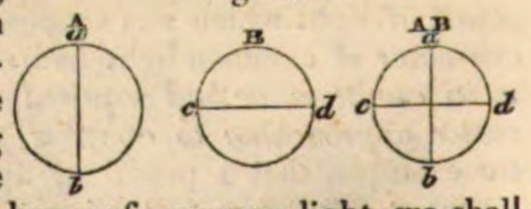
polarisation of the same pencil of light incident at the angles marked upon the curve line. At 90° of incidence, for example, the pencil A has its plane of polarisation inclined 45° to the plane of reflection M; but at 70° the same plane is inclined only 21°, and at 56° it is inclined 0°. At 40° it is inclined 23° in another direction; at 23° about 38°, and at 0° it is inclined 45°.

3. *On the partial Polarisation of Light, and the Law of its Intensity.*

In order to apply these results, Sir David Brewster conceives common light to be composed of two pencils A, B, fig. 136, having their planes of polarisation *ab*, *cd* at right angles to each other, and of equal intensity. Two such pencils united comports itself under all circumstances exactly like common light. We are as much entitled to consider a beam of common light as composed in this manner, as we are to regard white light as composed of seven differently refrangible rays. The prism analyses the one, and doubly-refracting crystals, and the action of transparent surfaces, analyse the other, and common light is recomposed by the two oppositely polarised pencils, as much as white light is recomposed by the union of the seven coloured rays. Considering common light in this manner, Sir David Brewster was led to obtain a complete explanation of the phenomena of polarisation produced by reflexion and refraction.

A beam of common light will be represented as at AB, composed of the two beams A, B, *ab* and *cd* being the planes of polarisation of each of them. In order, however, to analyse the action of a reflecting surface in changing the physical condition of the beam of common light, we shall represent it as in fig. 136, where the planes of polarisation *ab*, *cd* are each inclined 45° to the plane of incidence MN. These two beams are obtained from a rhomb of Iceland spar, upon one of whose surfaces is placed an aperture of the size of A or B, and the rhomb is turned round till its principal section is inclined 45° to the plane of incidence

Fig. 137.



Polarisation.

MN. In this position the double beam or pencil A, B will turn its planes of polarisation as in fig 136.

At an incidence of 90°, or as near it as possible, no change is produced in the pencils A, B, the angle *aec* being still 90°. At an incidence of 80° the angle *aec* is reduced from 90° to 66°; at 70° it has been reduced to 40°; and at 56°, the maximum polarising angle, it has been reduced to 0°, or the planes of polarization *ab*, *cd* being now parallel, or, what is the same thing, the whole of the reflected pencil being polarised in the plane of incidence. Below the polarising angle, the planes *ab*, *cd* continuing to turn in the same direction, are again inclined to each other. At 40° they are inclined 50°; at 23° they are inclined 38°; and at 0°, or a perpendicular incidence, they are again brought back to their primitive inclination of 90°, or the state of common light. The two curves in the figure show the progressive change which takes place in the planes of polarisation, these planes being a tangent to the curve at the incidence which corresponds to any particular part of it.

"Such," says Sir David Brewster,[1] "being the action of the reflecting forces upon A and B taken separately, let us now consider them as superposed and forming natural light. At 90° and 0° of incidence, the reflecting force produces no change in the inclination of their axes or planes of polarisation; but at 56° in the case of glass, and 67° 43′ in the case of diamond, the axes of all the particles are brought into a state of parallelism with the plane of reflection; and consequently when the image which they form is viewed by the rhomb of calcareous spar, they will all pass into the ordinary image, and thus prove that they are wholly polarised in the plane of reflection.

"Hence we see that the total polarisation of the reflected pencil at an angle whose tangent is the index of refraction, is effected by turning round the planes of polarisation of one half of the light from right to left, and of the other half from left to right, each through an angle of 45°. Let us now consider what takes place at those angles where the pencil is only partially polarised. At 80°, for example, the angle of the planes *a b*, *c d* is 66°, that is, each plane of polarisation has been turned round in opposite directions from an inclination of 45° to one of 33° with the plane of reflection. The light has therefore suffered a physical change of a very marked kind, constituting now neither natural nor polarised light. It is not natural light, because its planes of polarisation are not rectangular; it is not polarised light, because they are not parallel. It is a pencil of light having the physical character of one half of its rays being polarised at an angle of 66° to the other half. It will now be asked how a pencil thus characterised can exhibit the properties of a partially polarised pencil, that is, of a pencil part of whose light is polarised in the plane of reflection, while the rest retains its condition of natural light. This will be understood by placing the analysing rhomb, with its principal section, in the plane of reflection, and viewing through it the images A and B at 80° of incidence. As the axis of A is inclined 33° to MN or the section of the rhomb, the ordinary image of it will be much brighter than the extraordinary image, the intensity of each being in the ratio of $\cos.^2 \varphi$ to $\sin.^2 \varphi$, φ being the angle of inclination, or 33°, in the present case. In like manner, the ordinary image of B will be in the same ratio brighter than its extraordinary image, that is, by considering A and B in a state of superposition, the extraordinary image of a pencil of light reflected at 80° will be fainter than the ordinary image in the ratio of $\sin.^2 33°$ to $\cos.^2 33°$. But this inequality in the intensity of the two pencils is precisely what would be produced by a compound pencil, part of which is polarised in the plane of reflection, and part of which is common light.

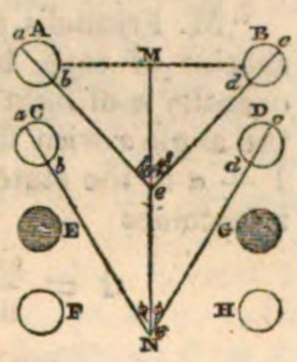
Polarisation.

When Malus, therefore, and his successors analysed the pencil reflected at 80°, they could not do otherwise than conclude that it was partially polarised, consisting partly of light polarised in the plane of reflection, and partly of natural light. The action of successive reflections, however, afforded a more precise means of analysis, in so far as it proved that the portion of what was deemed natural light had in reality suffered a physical change, which approximated it to the state of polarised light; and we now see that the portion of what was called polarised light was only what may be called apparently polarised; for though it disappears, like polarised light, from the extraordinary image of the analysing prism, yet there is not a single particle of it polarised in the plane of reflection.

"These results lead to conclusions of general importance. The quantity of light which disappears from the extraordinary image, is obviously the quantity of light which is really or apparently polarised at a given angle of incidence; and if we admit the truth of the law of repartition discovered by Malus, and represented by $P_{oo} = P_o \cos.^2 \varphi$, and $P_{oe} = P_o \sin.^2 \varphi$, and as we can determine φ for substances of every refractive power, and for all angles of incidence, we may consider as established the mathematical law which determines the intensity of the polarised pencil, whatever be the nature of the body which reflects it, whatever be the angle at which it is incident, whatever be the number of reflections which it suffers, and whether these reflections are all made from one substance, or partly from one substance and partly from another.

"Let us suppose that a beam of common light composed of two portions A, B (fig. 138) polarised + 45° and — 45° to the plane of reflection, is incident on a plate of glass at such an angle that the reflected pencil composed of C and D has its planes of polarisation inclined at an angle φ to the plane MN. When a rhomb of calcareous spar has its principal section in the plane MN, it will divide the image C into an extraordinary pencil E and an ordinary one F; and the same will take place with D, G being its extraordinary, and H its ordinary image. If we represent the whole of the reflected pencil, or C + D, by 1, then $C = \frac{1}{2}$, $D = \frac{1}{2}$, $E + F = 1$, and $G + H = 1$. But since the planes of polarisation of C and D are each inclined φ degrees to the principal section of the rhomb, the intensity of the light of the doubly-refracted pencils will be as $\sin.^2 \varphi : \cos.^2 \varphi$; that is, the intensity of E will be $\frac{1}{2} \sin.^2 \varphi$, and that of F, $\frac{1}{2} \cos.^2 \varphi$. Hence it follows that the difference of these pencils, or $\frac{1}{2} \sin.^2 \varphi - \frac{1}{2} \cos.^2 \varphi$, will express the quantity of light which has passed from the extraordinary image E into the ordinary one F; that is, the quantity of light apparently polarised in the plane of reflection MN. But as the same is true of the pencil D, we have $2 (\frac{1}{2} \sin.^2 \varphi - \frac{1}{2} \cos.^2 \varphi)$ or $\sin.^2 \varphi - \cos.^2 \varphi$ for the whole of the polarised light in a pencil of common light C + D. Hence, since $\sin.^2 \varphi + \cos.^2 \varphi = 1$, and $\cos.^2 \varphi = 1 - \sin.^2 \varphi$, we have for the whole quantity of polarised light

Fig. 138.



$$Q = 1 - 2 \sin.^2 \varphi.$$

But $$\tan. \varphi = \tan. x \frac{\cos. (i + i')}{\cos. (i - i')}$$

And as $\tan.^2 \varphi = \frac{\sin.^2 \varphi}{\cos.^2 \varphi}$, and $\sin.^2 \varphi + \cos.^2 \varphi = 1$,

we have the quotient and the sum of the quantities $\sin.^2 \varphi$ and $\cos.^2 \varphi$, by which we obtain

[1] Phil. Trans. 1830, p. 71.

Polarisation.

$$\sin.^2\varphi = \frac{1}{1 + \left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}$$

$$= \frac{\left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{1 + \left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}$$

$$\text{That is, } Q = 1 - 2\frac{\left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{1 + \left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}.$$

"As the quantity of reflected light is here supposed to be 1, we may obtain an expression of Q in terms of the incident light, by adopting the formula of Fresnel for the intensity of a reflected ray. Thus,

$$Q = \tfrac{1}{2}\left(\frac{\sin.^2(i-i')}{\sin.^2(i+i')} + \frac{\tan.^2(i-i')}{\tan.^2(i+i')}\right) \times \left(1 - 2\frac{\left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{1 + \left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}\right).$$

"As $\tan. x = 1$ in common light, it is omitted in the preceding formula.

"This formula may be adapted to partially polarised rays, that is, to light reflected at any angle different from the angle of maximum polarisation, provided we can obtain an expression for the quantity of reflected light.

"M. Fresnel's general formula has been adapted to this species of rays, by considering them as consisting of a quantity a of light completely polarised in a plane making the angle x with that of incidence, and of another quantity $1 - a$ in the state of natural light. Upon this principle it becomes

$$1 = \frac{\sin.^2(i-i')}{\sin.^2(i+i')} \cdot \frac{1 + a\cos.^2 x}{2} + \frac{\tan.^2(i-i')}{\tan.^2(i-i')} \cdot \frac{1 - a\cos.^2 x}{2}.$$

"But as we have proved that partially polarised rays are rays whose planes of polarisation form an angle of $2x$ with one another as already explained, x being greater or less than 45°, we obtain a simpler expression for the intensity of the reflected pencil, viz. the very same as that for polarised light.

$$1 = \frac{\sin.^2(i-i')}{\sin.^2(i+i')}\cos.^2 x + \frac{\tan.^2(i-i')}{\tan.^2(i+i')}\sin.^2 x.$$

Hence we have

$$Q = \left(\frac{\sin.^2(i-i')}{\sin.^2(i+i')}\cos.^2 x + \frac{\tan.^2(i-i')}{\tan.^2(i+i')}\sin.^2 x\right), \left(1 - 2\frac{\left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{+\left(\tan. x \frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}\right).$$

"This formula is equally applicable to a single pencil of polarised light of the same intensity as the pencil of partially polarised light. In all these cases it expresses the quantity of light really or apparently polarised in the plane of reflection.

"In order to show the quantity of light polarised at different angles of incidence, I have computed the following table for common light, and suited to glass in which $m = 1{\cdot}525$.

Polarisation.

Angle of Incidence i.	Angle of Refraction i'.	Inclination of Plane of Polarisation to Plane of Reflection, φ.	Quantity of Light Reflected out of 1000 Rays.	Quantity of Polarised Light Q.	Ratio of Polarised to Reflected Light.
0° 0′	0° 0′	45° 0′	43·23	0	0
10 0	6 32	43 51	43·39	1·74	0·04000
20 0	12 58	40 13	43·41	7·22	0·16618
25 0	16 5	37 21	43·64	11·6	0·26388
30 0	19 8½	33 40	44·78	17·25	0·3853
35 0	22 6	29 8	46·33	24·37	0·5260
40 0	24 56	23 41	49·10	33·25	0·6773
45 0	27 37½	17 22½	53·66	44·09	0·82167
50 0	30 9	10 18	61·36	57·36	0·9360
56 45	33 15	0 0	79·5	79·5	1·000
60 0	34 36	5 4½	93·31	91·6	0·9628
65 0	36 28	12 45	124·86	112·7	0·90258
70 0	38 2	18 32	162·67	129·80	0·79794
75 0	39 18	26 52	257·26	152·34	0·59154
78 0	39 54	30 44	329·95	457·67	0·47786
79 0	40 4	31 59	359·27	157·69	0·43892
80 0	40 13	33 13	391·7	156·6	0·40000
82 44	40 35	36 22	499·44	145·4	0·29112
84 0	40 42	38 2	560·32	134·93	0·2408
85 0	40 47	39 12	616·28	123·75	0·2008
86 0	40 51	40 22·7	676·26	108·67	0·16068
87 0	40 54	41 32	744·11	89·83	0·12072
88 0	40 57½	42 42	819·9	65·9	0·0804
89 0	40 58	43 51	904·81	36·32	0·04014
90 0	40 58	45 0	1000·0	0	0·0000

"As the preceding formula is deduced from principles which have been either established by experiment or confirmed by it, it may be expected to harmonize with the results of observation. At all the limits where the pencil is either wholly polarised or not polarised at all, it of course corresponds with experiment; but though, in so far as I know, there have been no absolute measures taken of the quantity of polarised light at different incidences, yet we are fortunately in possession of a set of experiments by M. Arago, who has ascertained the angles above and below the polarising angle at which glass and water polarise the same proportion of light. In no case has he measured the absolute quantity of the polarised rays; but the comparison of the values of Q at those angles at which he found them in equal proportions, will afford a test of the accuracy of the formula. This comparison is shown in the following table, in which column 1 contains the angles at which the reflecting surface polarises equal proportions of light; column 2 the values of φ, or the inclination of the planes of polarisation; and column 3 the intensities of the polarised light computed from the formula.

		Angles of Incidence.	Inclination of Planes of Polarisation to MN, or φ.	Proportion of Polarised Light, or Q.
Glass:	No. 1.	82° 48′	37° 33′	·2572
		24 18	37 21	·2637
	No. 2.	82 5	36 47	·2828
		26 6	36 0	·3090
	No. 3.	78 20	32 38	·4186
		29 42	33 1	·4064
Water:	No. 4.	86 31	41 54	·1080
		16 12	41 27	·1236

"The agreement of the formula with experiments made with as great accuracy as the subject will admit, must be allowed to be very satisfactory. The differences are within the limits of the errors of observation, as appears from the following table:

		Deviations from Experiment.	Part of the whole Light.
Glass:	No. 1.	0·0065	$\frac{1}{154}$
	No. 2.	0·0262	$\frac{1}{38}$
	No. 3.	0·0122	$\frac{1}{82}$
Water:	No. 4.	0·0156	$\frac{1}{64}$

"M. Arago has concluded, from the experiments above stated, that equal proportions of light are polarised at equal

Polarisation.

angular distances from the angle of complete polarisation. Thus, in glass No. 1, the mean of 82° 48′ and 24° 18′ is 53° 33′, which does not differ widely from the maximum polarising angle, or 55°, which M. Arago considers as the maximum polarising angle of the glass.[1] In order to compare this principle with the formula, I found, that in water No. 4, the angle which polarises almost exactly the same proportion of light as the angle of 86° 31′, is 15° 10′, the value of φ being 41° 54′ at both these angles; but the mean of these is 50° 50′ in place of 53° 11′, so that the rule of M. Arago cannot be regarded as correct, and cannot therefore be employed, as he proposes, to determine the angle of complete polarisation."[2]

4. *On the Law of the Polarisation of Light by successive Reflections.*

We come now to show the application of the preceding law of intensity to the phenomena of the polarisation of light by successive reflections.

"When a pencil of common light," says Sir David Brewster,[3] "has been reflected from a transparent surface, at an angle of 61° 3′, for example, it has experienced such a physical change that its planes of polarisation form an angle of 6° 45′ each with the plane of reflection. When it is incident on another similar surface at the same angle, it is no longer common light, in which $x = 45°$, but it is partially polarised light, in which $x = 6°$ 45′. In computing, therefore, the effect of the second reflection, we must take the general formula tan. φ = tan. $x \left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)$; but as the value of x is always in the same ratio to the value of φ, however great be the number of reflections, we have tan. θ = tan.^{n} φ for the inclination θ to the plane of reflection produced by any number of reflections n, φ being the inclination for one reflection. Hence, when θ is given by observation, we have tan. $\varphi = \sqrt[n]{\theta}$. The formula for any number n of reflections is therefore tan. $\theta = \left(\frac{\cos.(i+i')}{\cos.(i+i')}\right)^n$. It is evident that θ never can become equal to 0°; that is, that the pencil cannot be so completely polarised by any number of reflections at angles different from the polarising angle, as it is by a single reflection at the polarising angle; but we shall see that the polarisation is sensibly complete, in consequence of the near approximation of θ to 0°.

"I found, for example, that light was polarised by two reflections from glass at an angle of 61° 3′, and 60° 28′ by another observation. Now, in these cases, we have

	θ after 1st Reflection.	θ after 2d Reflection.	Quantity of Unpolarised Light.
two reflections at 61°	3′	6° 45′	0·00037
60	28	5 38	0·00018

The quantity of unpolarised light is here so small as to be quite unappreciable with ordinary lights.

"In like manner, I found that light was completely polarised by five reflections at 70°. Hence, by the formula, we have

	Values of θ.	Unpolarised Light.
1 reflection at 70°	20° 0′	0·23392
2	7 32	0·03432
3	2 45	0·00460
4	1 0	0·00060
5	0 22	0·00008

The quantity of unpolarised light is here also unappreciable after the fifth reflection. Polarisation.

In another experiment it was found that light was wholly polarised by the separating surface of glass and water at the following angles:

	Values of θ.	Unpolarised Light.
By 2 reflections at 44° 51′	0° 56′	0·0005
By 3	42 27	0 26 0·0001

"In all these cases the successive reflections were made at the same angle; but the formula is equally applicable to reflections at different angles,—

"1. When both the angles are greater than the polarising angle,—

	θ.	Unpolarised Light.
1 reflection at 58° 2′, and 1 at 67° 2′	0° 34′	0·0002

"2. When one of the angles is above and the other below the polarising angle,—

	θ.	Unpolarised Light.
1 reflection at 53°, and 1 at 58° 2′	0° 12′	0·000024

This experiment requires a very intense light; for I find in my journal that the light of a candle is polarised at 53° and 78°.

"In reflections at different angles, the formula becomes tan. $= \frac{\cos.(i+i')}{\cos.(i-i')} \times \frac{\cos.(I+I')}{\cos.(I+I')}$, I and i being the angles of incidence. In like manner, if a, b, c, d, e, &c. are the values of φ or θ for each reflection, or rather for each angle of incidence, we shall have the final angle, or tan. θ = tan. $a \times$ tan. $b \times$ tan. $c \times$ tan. d, &c.

"It is scarcely necessary to inform the reader, that when a pencil of light reflected at 58° 2′ is said to be polarized by another reflection at 67° 2′, it only means, that this is the angle at which complete polarisation takes place in diminishing the angle gradually from 90° to 67° 2′, and that even this angle of 67° 2′ will vary with the intensity of the original pencil, with the opening of the pupil, and with the sensibility of the retina. But when it shall be determined experimentally at what value of φ, or rather at what value of Q, the light entirely disappears from the extraordinary image, we shall be able, by inverting the formula, to ascertain the exact number of reflections by which a given pencil of light shall be wholly polarised.

"As the value of Q depends on the relation of i and i', that is, on the index of refraction, and as this index varies for the different colours of the spectrum, it is obvious that Q will have different values for these different colours. The consequence of this must be, that in bodies of high dispersive powers, the unpolarised light which remains in the extraordinary image, and also the light which forms the ordinary image, must be coloured at all incidences; the colours being most distinct near the maximum polarising angle. This necessary result of the formula was found to be experimentally true in oil of cassia, and various highly dispersive bodies. In realgar, for example, φ is = 0 at an angle of 69° 0′ for blue light, at 68° 37′ for green light, and at 66° 49′ for red light. Hence there can be no angle of complete polarisation for white light, which was also found to be the case by experiment; and as Q must at different angles of incidence have different values for the different rays, the unpolarised light must be composed of a certain portion of each different colour, which may be easily determined by the formula.

"Such are the laws which regulate the polarisation of

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[1] Hence we have assumed $m = 1{\cdot}428$, the tangent of 55°, in the preceding calculations.
[2] It is obvious that the rule can only be true when $m = 1{\cdot}000$; so that its error increases with the refractive power.
[3] Phil. Trans. 1830, p. 80.

Polarisation. light by reflection from the first surfaces of bodies that are not metallic. The very same laws are applicable to their second surfaces, provided that the incident light has not suffered previous or subsequent refraction from the first surface. The sine of the angle at which φ or Q has a certain value by reflection from the second surface, is to the sine of the angle at which they have the same value at the first surface, as unity is to the index of refraction. Hence φ and Q may be determined by the preceding formulæ after any number of reflections, even if some of the reflections are made from the first surface of one body and the second surface of another."

Sect. III.—*On the Polarisation of Light by Refraction.*

We have already seen that the polarisation of light by refraction was discovered by independent observations by Malus, Biot, and Brewster; but the priority of discovery belongs to Malus, who, from various observations, arrived at the following conclusion: "When a ray of light falls upon a plate of glass at an angle of 54° 35′, all the light which it reflects is polarised in one direction. The light which traverses the glass is composed, 1*st*, of a quantity of light polarised in a direction opposite to that which is reflected, and proportional to it; and, 2*dly*, of another portion not modified, and which preserves the character of direct light."

Sir David Brewster made analogous experiments with thin films of glass, films of mica, folds of gold-beaters' skin, and films of gold leaf; but he occupied himself chiefly in determining the law of the phenomena depending on the number of plates through which the light was transmitted, and found *that the number of plates which polarise a maximum of light by transmission at different angles of incidence, are to one another as the co-tangents of the angles of incidence.*

In determining this law, our author employed forty-seven plates of crown-glass, each about three inches long and one broad, and with these he obtained the following results:—

Number of Plates in each Parcel.	Angles of Incidence at which Light is Polarised, by Calculation.	Angles of Incidence at which Light is Polarised, by Experiment.	Differences between the Calculated and Observed Angles.
8	79° 11′	78° 52′ [1]	0 19′ —
10	76 33	76 24	0 9 —
12	74 0	74 2	0 2 +
14	71 30	72 15	0 45 +
16	69 4	69 40	0 36 +
18	66 43	66 43	0 0
21	63 21	63 39	0 18 +
24	60 8	61 0	0 52 +
27	57 10	56 58	0 12 —
29	55 16	54 50	0 26 —
31	53 28	53 16	0 12 —
33	51 44	51 0	0 44 —
35	50 5	50 23	0 18 +
39	47 1	46 50	0 11 —
41	45 35	45 49	0 14 +
44	43 34	44 0	0 26 +
47	41 41	42 0	0 19 +
100	22 42		
200	11 49		
500	4 47		
1,000	2 24		
2,000	1 12		
4,000	0 36		
14,000	0 1		
8,640,000	0 0 1″		

[1] This result was obtained by a parcel of plates of parallel glass.

If n, n', therefore, represent the number of plates in any two parcels, and φ, φ the angles at which the pencil was polarised, we have Polarisation.

$$n : n' = \text{cotan. } \varphi : \text{cotan. } \varphi,' \text{ and}$$
$$n \times \text{tan. } \varphi = n' \times \text{tan. } \varphi'.$$

That is, the *number of plates in any parcel, multiplied by the tangent of the angle at which it polarises light, is a constant quantity.* From a great number of observations made with a parcel of eighteen plates, our author found the constant quantity for crown-glass to be 41·84 when the light was that of a good wax-candle placed at the distance of about twelve feet, so that we have

$$\text{tan. } \varphi = \frac{41{\cdot}84}{n};$$

that is, divide the constant quantity by any given number of plates, and the quotient will be the natural tangent of the angle at which that number will polarise a pencil of light.

In this way the *second* column of the table, which differs very little from the observed column, was computed.

From these experiments our author drew the same conclusion as in the case of reflection, respecting the state of what Malus calls the unpolarised light, namely, that it had suffered a physical change; and he also showed that light could be polarised by successive refractions, each refraction bringing it gradually nearer and nearer to the state of complete polarisation.

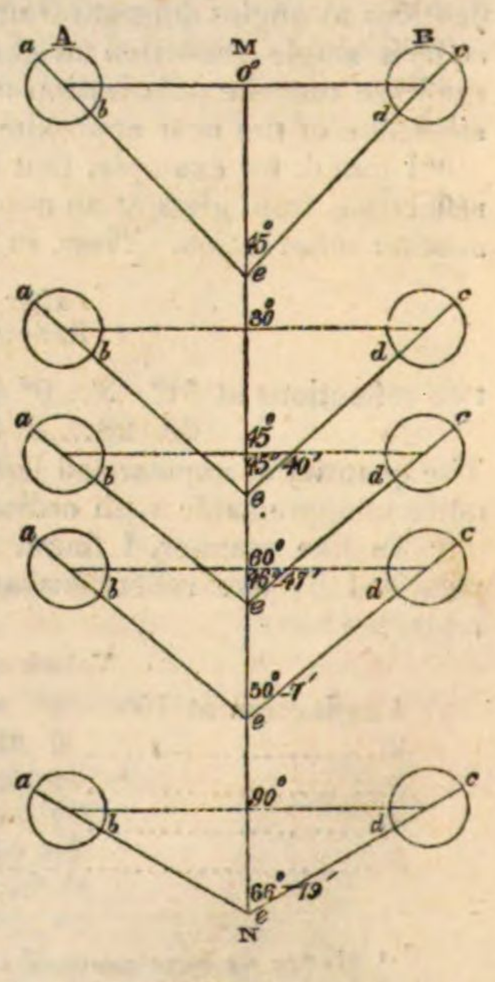
1. *On the Motion of the Planes of Polarisation by Refraction.*

The first, and we believe the only, experiments that have been made on this subject, were those of Sir David Brewster;[1] and we shall therefore give an account of his researches in his own words, abridging it as much as possible.

"If we take a plate of glass, deviating so slightly from parallelism between its faces as to throw aside from the direct transmitted image of a luminous body the faint images formed by reflection between its inner surfaces, we shall obtain, even at the greatest obliquities, a pencil of light free of all admixture of reflected light.

"Let this plate be placed upon a divided circle, so that we can observe through it two luminous discs of polarised light A, B (fig. 139) formed by double refraction, and having their planes of polarisation inclined + 45° and — 45° to the plane of refraction. At a perpendicular incidence, the inclination of the planes of polarisation will suffer no change; but at an incidence of 30° they will be turned round 40′, so that their inclination to MN or the angle *aec* will be 45° 40′. At 45° their inclination will be 46° 47′. At 60° it will be 50° 7′; and it will increase gradually to 90°, where it becomes 66° 19′. Hence the maximum change produced by a single plate of glass upon the planes of polarisation is 66° 19′ — 45° = 21° 19′, an effect exactly equal to

Fig. 139.



[1] Phil. Trans. 1830, p. 133.

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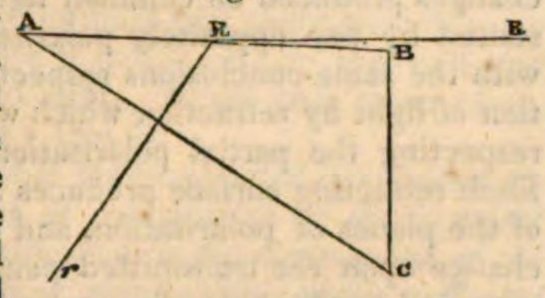
what is produced by reflection at angles of 39° or 70°. It is remarkable, however, *that this change is made in the opposite direction, the planes of polarisation now approaching to coincidence in a plane at right angles to that of reflection;* a difference which might have been expected from the opposite character of the resulting polarisation.

"In this experiment the action of the two surfaces is developed in succession, so that we cannot deduce from the maximum rotation of 21° 19′, the real action of the first, or of a single surface, which must be obviously more than half of the action of the two surfaces, because the planes of polarisation have been widened before they undergo the action of the second surface.

"In order to obtain the rotation due to a single surface, I took a prism of glass ABC, having such an angle BAC, that a ray RR, incident as obliquely as possible, should emerge in a direction Rr perpendicular to the surface AC. I took care that this prism was well annealed, and I caused the refraction to be performed as near as possible to the vertex A, where the glass was thinnest, and consequently most free from the influence of any polarising structure. In this way I obtained the following measures.

Fig. 140.



Glass.

Angles of Incidence.	Inclination of Planes *ab*, *cd*, to the Plane of Reflection.	Rotation of Plane for one Surface.
87° 38′	54° 15′	9° 15′
54 50	47 25	2 25
32 20	45 22	0 22

"I next made the following experiments with two kinds of glass, the one a piece of parallel plate-glass, and the other a piece of very thin crown. The latter had the advantage of separating the reflected from the transmitted light.

Plate Glass.			*Crown Glass.*	
Incidence.	Inclination.	Rotation for two Surfaces.	Inclination.	Rotation for two Surfaces.
0°	45° 0′	0° 0′	45° 0′	0° 0′
40	47 28	2 28	47 18	2 18
55	49 35	4 35	49 19	4 19
67	52 53	7 53	58 16	7 16
80	58 53	13 53	58 42	13 42
86½	61 16	16 16	61 0	16 0

"In order to ascertain the influence of refractive power, I stretched a film of soapy water across a rectangular frame of copper wire, and obtained the following measures:

Water.

Incidence.	Inclination.	Rotation.
85°	54° 17′	9° 17′

Metalline Glass.

0	45 0	0 0
20	45 42	0 42
30	46 50	1 50
40	48 0	3 0
55	51 12	6 12
80	62 32	17 32

"From a comparison of these results, it is manifest that *the rotation increases with the refractive power.*

"In examining the effects produced at different incidences, it is obvious that the rotation R varies with the deviation of the refracted ray; that is, with $i - i'$. Hence I have been led to express the inclination φ of the planes of polarisation to the plane of refraction and the rotation by the formulæ

$$\cot.\ \varphi = \cos.\ (i - i'), \qquad R = \varphi - 45°.$$

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"This formula represents the experiments so accurately, that when the rhomb of calcareous spar is set to the calculated angle of inclination, the extraordinary image is completely invisible.

"The above expression is of course suited only to the case where the inclination x of the planes of polarisation *ab*, *cd* (fig. 139), is 45°; but when this is not the case, the general expression is

$$\cot.\ \theta = \cot.\ x \cos.\ (i - i').$$

"When the light passes through a second surface, as in a single plate of glass, the value of x for the second surface is evidently the value of φ after the first refraction; or, in general, calling θ the inclination after any number n of refractions, and φ the inclination after one refraction,

$$\cot.\ \theta = (\cot.\ \varphi)^n.$$

"When θ is given by observation we have

$$\cot.\ \varphi = \sqrt[n]{\cot.\ \theta}.$$

"The general formula for any inclination x and any number n of refractions is

$$\cot.\ \theta = \big(\cot.\ x \cos.\ (i - i')\big)^n, \text{ and}$$

$$\cot.\ \varphi = \sqrt[n]{\cot.\ x \cos.\ (i - i')}.$$

"And when $x = 45°$ and $\cot.\ x = 1$, as in common light,

$$\cot.\ \theta = \big(\cos.\ (i - i')\big)^n,$$

$$\cot.\ \varphi = \sqrt[n]{\cos.\ (i - i')}.$$

"As the term $\big(\cos.\ (i - i')\big)^n$ can never become equal to 0, the planes of polarisation can never be brought into a state of coincidence in a plane perpendicular to that of reflection.

"In order to compare the formula with experiment, I took a plate of well-annealed glass, which at all incidences separates the reflected from the transmitted rays, and in which m was nearly 1·510, and I obtained the following results:

Angles of Incidence.	Angles of Refraction.	Rotation observed.	Inclination observed.	Inclination calculated.	Difference.
0°	0° 0′	0° 0′	45° 0′	45° 0′	
10	6 36½	0 13	45 13	45 6	+0° 7′
20	13 5	0 27	45 27	45 25	+0 2
25	16 15	0 32	45 32	45 40	−0 8
30	19 20	0 40	45 40	46 0	−0 20
35	22 19	1 12	46 12	46 25	−0 13
40	25 10	1 30	46 30	46 56	−0 26
45	27 55	1 42	46 47	47 34	+0 47
50	30 29	2 48	47 42	48 24	−0 42
55	33 52	3 54	48 54	48 59	−0 5
60	35 0	5 7	50 7	50 36	−0 29
65	36 53	6 48	51 48	52 7	−0 19
70	38 29	8 7	53 7	53 59	−0 52
75	39 45	9 55	54 55	56 18	−1 23
80	40 42	12 10	57 10	59 5	−1 55
85	41 19	15 45	60 45	62 24	−1 39
86	41 21	16 39	61 39	63 9	−1 30
90	41 28			66 19	

"The last column but one of the table was calculated by the formula

$$\cot.\ \theta = \cos.\ \big(\cos.\ (i - i')\big)^2,$$

n being in this case 2. The errors, however, being almost all negative, I suspected that there was an error of adjustment in the apparatus; and upon repeating the experiment at 80°, the point of maximum error, I found that the inclination was fully 58° 40′, giving a difference only of 25 in place of 1° 55′.

"In these experiments $x = 45°$ and $\cot.\ x = 1$; but in order to try the general formula when x varied from 0° to 90°, I took the case where the angle of incidence was 80°,

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and $\varphi = 58° 40'$ when $x = 45°$. The following were the results.

Values of x.	Inclination observed.	Inclination calculated.	Difference.
0°	0° 0′	0° 0′	0° 0′
$2\frac{1}{2}$	7 10	7 20	— 0 10
5	9 40	8 19	+ 1 21
10	17 10	16 25	+ 0 45
15	24 42	24 6	+ 0 36
20	32 30	31 19	+ 1 11
25	39 15	37 54	+ 1 21
30	44 10	43 57	+ 0 13
35	49 38	49 28	+ 0 10
40	54 36	54 31	+ 0 5
45	58 40	59 5	— 0 25
50	63 10	63 19	— 0 9
55	66 58	67 15	— 0 17
60	70 18	70 56	— 0 38
65	74 8	74 24	— 0 16
70	76 56	77 42	— 0 46
75	79 20	80 53	— 1 33
80	83 23	83 58	— 0 35
85	86 23	86 0	+ 0 23
90	90 0	90 0	0 0

"The last column but one was calculated by the formula $\cot. \theta = \cot. x \,.\, (\cot. 58° 40')^2$.

"In determining the quantity of polarised light in the refracted pencil, we must follow the method already explained for the reflected ray, *mutatis mutandis*. The principal section of the analysing rhomb being now supposed to be placed in a plane perpendicular to the plane of reflection, the quantity of light Q' polarised in that plane will be

$$Q' = 1 - 2 \cos.^2 \varphi,$$

the quantity of transmitted light being unity. But

$$\cot. \varphi = \cot. x \cos. (i - i'),$$

and as $\cot. \varphi = \frac{\cos.^2 \varphi}{\sin.^2 \varphi}$, and $\sin.^2 \varphi + \cos.^2 \varphi = 1$, we have the quotient and the sum of $\sin.^2 \varphi$ and $\cos.^2 \varphi$ to find them.

$$\text{Hence } \cos.^2 \varphi = \frac{(\cot. x \cos. (i - i'))^2}{1 + (\cot. x \cos. (i - i'))^2};$$

and by substituting this for $\cos.^2 \varphi$ in the former equation, it becomes

$$Q' = 1 - 2 \frac{(\cot. x \cos. (i - i'))^2}{1 + (\cot. x. \cos. (i - i'))^2}.$$

"Now since, by Fresnel's formula, the quantity of reflected light is

$$R = \tfrac{1}{2} \left(\frac{\sin.^2 (i - i')}{\sin.^2 (i + i')} + \frac{\tan.^2 (i - i')}{\tan.^2 (i + i')} \right),$$

the quantity of transmitted light T will be

$$T = 1 - \tfrac{1}{2} \left(\frac{\sin.^2 (i - i')}{\sin.^2 (i + i')} + \frac{\tan.^2 (i - i')}{\tan.^2 (i + i')} \right).$$

$$\text{Hence } Q' = \left(1 - \tfrac{1}{2} \left(\frac{\sin.^2 (i - i')}{\sin.^2 (i + i')} + \frac{\tan.^2 (i - i')}{\tan.^2 (i + i')} \right) \right) \left(1 - 2 \frac{(\cos. (i - i'))^2}{1 + (\cos. (i - i'))^2} \right).$$

"This formula is applicable to common light, in which $\cot. x = 1$ disappears from the equation; but, on the same principles which we have explained in a preceding paper, it becomes for partially polarised rays and for polarised light,

$$Q' = \left(1 - \tfrac{1}{2} \left(\frac{\sin.^2 (i - i')}{\sin.^2 (i + i')} \cos.^2 x + \frac{\tan.^2 (i - i')}{\tan.^2 (i + i')} \sin.^2 x \right) \right) \left(1 - 2 \frac{(\cot. x \cos. (i - i'))^2}{1 + (\cot. x \cos. (i - i'))^2} \right).$$

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"In all these cases the formula expresses the quantity of light really or apparently polarised in the plane of refraction.

"As the planes of polarisation of a pencil polarised + 45° and — 45° cannot be brought into a state of coincidence by refraction, the quantity of light polarised by refraction can never be mathematically equal to the whole of the transmitted pencil, however numerous be the refractions which it undergoes; or, what is the same thing, refraction cannot produce rays truly polarised, that is, with their planes of polarisation parallel."

2. *On the partial Polarisation of Light by one or more Refractions.*

"The analysis given in the preceding paragraphs, of the changes produced on common light, considered as represented by two oppositely polarised pencils, furnishes us with the same conclusions respecting the partial polarisation of light by refraction which we have already deduced respecting the partial polarisation of light by reflection. Each refracting surface produces a change in the position of the planes of polarisation, and consequently a physical change upon the transmitted pencil by which it has approached to the state of complete polarisation.

"This position I shall illustrate by applying the formula to the experiments in a preceding page.

"According to the first of these, the light of a wax-candle at the distance of ten or twelve feet is wholly polarised by eight plates or sixteen surfaces of parallel plate-glass at an angle of 78° 52′. Now I have ascertained that a pencil of light of this intensity will disappear from the extraordinary image, or appear to be completely polarised, provided its planes of polarisation do not form an angle of less than $88\frac{3}{4}°$ with the plane of refraction for a moderate number of plates, or $88\frac{1}{2}°$ for a considerable number of plates, the difference arising from the great diminution of the light in passing through the substance of the glass. In the present case the formula gives

$$\cot. \theta = \left(\cos. (i - i') \right)^{16} \text{ and } \theta = 88° 50';$$

so that the light should appear to be completely polarised, as it was found to be.

"At an angle of 61° 0′ the pencil was polarised by twenty-four plates or forty-eight surfaces. Here

$$\cot. \theta = \left(\cos. (i - i') \right)^{48} = 89° 36'.$$

"At an angle of 43° 34′ the light was polarised by forty-seven plates or ninety-four surfaces. Here

$$\cot. \theta = \left(\cos. (i - i') \right)^{94} \text{ and } \theta = 88° 27'.$$

"It is needless to carry this comparison any further; but it may be interesting to ascertain by the formula the smallest number of refractions which will produce complete polarisation. In this case the angle of incidence must be 90°.

"Hence, $\varphi = 56° 29'$ and $\left(\cos. (i - i') \right)^9$ gives 88° 36′, and $\left(\cos. (i - i') \right)^{10}$ 89° 4′; that is, the polarisation will be nearly complete by the most oblique transmission through four and a half plates or nine surfaces, and will be perfectly complete through five plates or ten surfaces."

Sect. IV.—*Comparison of the Laws of Intensity for Light polarised by Reflection and Refraction.*

"Having obtained formulæ for the quantity of light polarised by refraction and reflection, it becomes a point of great importance to compare the results which they furnish. Calling R the reflected light, these formulæ become

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$$Q = R\left(1 - 2\frac{\left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}{1+\left(\frac{\cos.(i+i')}{\cos.(i-i')}\right)^2}\right), \text{ and}$$

$$Q' = 1 - R\left(1 - 2\frac{(\cos.(i-i'))^2}{\varphi + (\cos.(i-i'))^2}\right).$$

"But these two quantities are equal, and hence we obtain the important general law, that,—*At the first surface of all bodies, and at all angles of incidence, the quantity of light polarised by refraction is equal to the quantity polarised by reflection. I have said 'of all bodies,' because the law is equally applicable to the surfaces of crystallized and metallic bodies, though the action of their first surface is masked or modified by other causes.*

"It is obvious from the formula that there must be some angle of incidence where R = 1 — R, or the reflected equal to the transmitted light. When this takes place, we have $\sin.^2 \varphi = \cos.^2 \varphi'$; that is,

"*The reflected is equal to the transmitted light, when the inclination of the planes of polarisation of the reflected pencil to the plane of reflection, is the complement of the inclination of the planes of polarisation of the refracted pencil to the same plane;* or, if we refer the inclination of the planes to the two rectangular planes into which the planes of polarisation are brought,—*The reflected will be equal to the transmitted light when the inclination of the planes of polarisation of the reflected pencil to the plane of reflection is equal to the inclination of the plane of polarisation of the refracted pencil to a plane perpendicular to the plane of reflection.*

"In the following table, the inclination of the planes of polarisation of the reflected and the refracted pencil, and the quantities of light reflected, transmitted, and polarised, at all angles of incidence upon glass, *m* being equal to 1·525, and the incident light = 1000, are given:

Angles of Incidence, *i*.	Angles of Refraction, *i'*.	Inclination of Plane of Polarisation of the Reflected Light, φ'.	Inclination of Plane of Polarisation of the Refracted Light, φ.	Quantity of Light Reflected, R.	Quantity of Light Transmitted, 1 — R.	Quantity of Light Polarised, Q.
0° 0′	0° 0′	45° 0′	45° 0′	43·23	956·77	0·
2 0	1 18⅔	44 57	45 0·7	43·26	956·74	0·07
10 0	6 32	43 51	45 3	43·39	956·61	1·73
20 0	12 58	40 13	45 13	43·41	956·59	7·22
25 0	16 5	37 21	45 21	43·64	956·36	11·6
30 0	19 8½	33 40	45 31	44·78	955·22	17·24
35 0	22 6	29 8	45 44	46·33	953·67	24·4
40 0	24 56	23 41	46 0	49·10	950·90	32·2
45 0	27 37½	17 22½	46 20	53·66	946·33	44·0
50 0	30 9	10 18	46 45	61·36	938·64	57·4
56 45	33 15	0 0	47 29	79·5	920·5	79 5
60 0	34 36	5 4½	47 54½	93·31	906·69	91·6
65 0	36 28	12 45	48 42	124·86	875·14	112·7
70 0	38 2	18 32	49 28	162·67	837·33	129·8
75 0	39 18	26 52	50 55	257·56	742·44	152·3
78 0	39 54	30 44	51 48	329·95	670·05	157·6
78 7	39 55	30 53	51 50	333·20	666·80	157·65
79 0	40 4	31 59	52 7	359·27	640·73	157·6
80 40	40 13	33 13	52 27½	391·7	608·3	156·7
82 4	40 35	36 22	53 26⅓	499·44	500·56	145·4
84 0	40 42	38 2	53 57	560·32	439·68	134·93
85 0	40 47	39 12	54 22	616·28	383·72	123·7
85 50⅔	40 50⅔	40 12	54 44	666·44	333·56	111·11
86 0	40 51	40 22 7/10	54 48	676·26	323·74	108·67
87 0	40 54	41 32	55 16	744·11	255·89	89·8
88 0	40 57½	41 23	55 43	819·9	180·1	65·9
89 0	40 58	43 51	56 14	904·81	95·19	36·3
90 0	40 58	45 0	56 29	1000·	·0·	0·

"It is obvious, from a consideration of the principle of the formula for reflected light, that the quantity of polarised light is nothing at 0°, because the force which polarises it is there a minimum. At the maximum polarising light, Q is only 79·5, because the glass is incapable of reflecting more light at that angle, otherwise more would have been polarised. The value of Q, then, rises to its maximum at 78° 7′, and descends to its minimum at 90°; but the polarising force has not increased from 56° 45′ to 78° 7′, as the value of φ' shows. It is only the quantity of reflected light that has increased which occasions a greater quantity of light to disappear from the extraordinary image of the analysing rhomb.

"The case, however, is different with the refracted light. The value of Q′ has one minimum at 0°, and another at 90°, while its maximum is at 78° 7′; while the force has its minimum at 0°, and its minimum at 90°, where its effect is a minimum only because there is no light to polarise. At the incidence of 78° 7′, where the quantities Q, Q′ reach their maxima, the reflected light is exactly one half of the transmitted light; $\sin.^2 \varphi' = \cos.^2 \varphi$ and $\tan. \varphi' = \cos. \varphi$.

"At 85° 50′ 40″, where the transmitted light is one half of the reflected light, the deviation $(i - i') = 45°$, and the quantity of polarised light is one third of the transmitted light, one sixth of the reflected light, and one ninth of the incident light. $\sin.^2 \varphi' : \cos.^2 \varphi$ = reflected light: transmitted light, and $\cot. \varphi = \sin.(i - i')$.

"At 45° we have $(i+i')+(i-i')=90°$ and $\varphi'=(i-i')$, $\tan.(i-i')=\frac{\cos.(i+i')}{\cos.(i-i')}$, and $\tan.(i-i')^2=\frac{(\sin.(i-i'))^2}{(\sin.(i+i'))^2}$.

"At 56° 45′, the polarising angle, the formula for reflected light becomes $R = \frac{1}{2}(\sin.^2(i-i'))^2$; but at this angle we have $i' = 90° - i$. Hence we obtain the following simple expression in terms of the angle of incidence, for the quantity of light reflected by all bodies at the polarising angle:

$$R = \tfrac{1}{2}(\cos. 2i)^2."$$

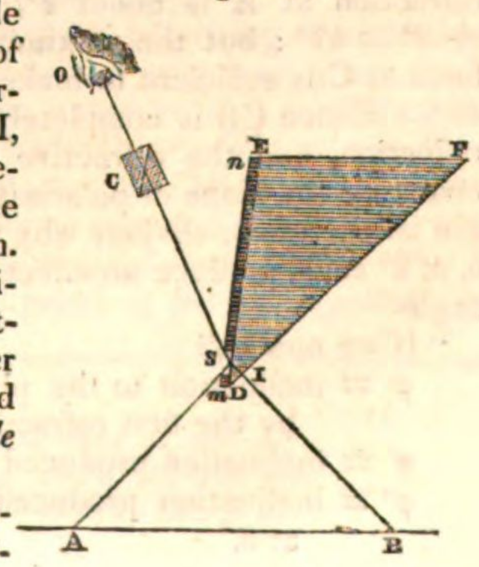
Sect. V.—*On the Action of Single Plates and Single Surfaces in polarising Light by Reflection and Refraction.*

In the article on the *polarisation* of light in this work, M. Arago has described an elegant experiment, from which he deduced the conclusion, that *the quantity of polarised light contained in the pencil transmitted by a transparent plate is exactly equal to the quantity of light polarised at right angles, which is found in the pencil reflected by the same plate.*

Now this law is true only at the maximum polarising angle, the two pencils being unequal at all other angles of incidence. The apparent equality observed by M. Arago seems to have arisen from other light being blended with the pencils. In order, therefore, to obtain the true law for single plates, we must determine it for a *single surface.*

In order to do this, Sir David Brewster employed a well-annealed prism of colourless glass, in place of a plate of glass, and he made the ray BI from a sheet of white paper BA enter the surface FD perpendicularly at I, while another ray AS was reflected to the eye from the surface ED of the prism. He then made the experiment with a doubly refracting prism C in the manner described by M. Arago, and obtained the law for *a single surface*, viz.

Fig. 141.



That the quantity of polarised light in the pencil re-

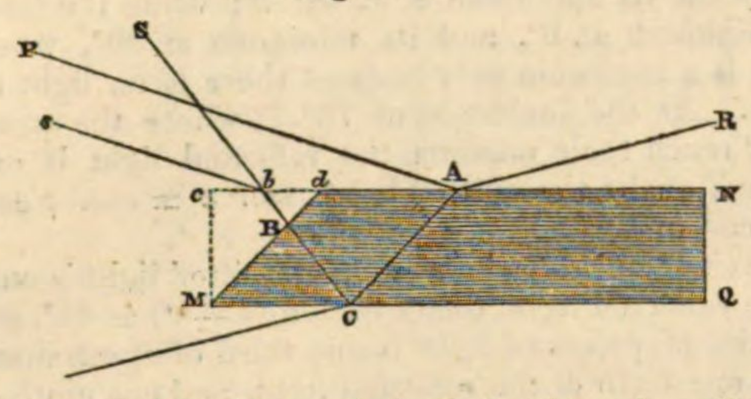
Polarisation. *fracted by a transparent surface is exactly equal to the quantity in the pencil reflected by it.*

That is, what was supposed to be true of plates is true only of surfaces.

The action of a single plate on light, involving the combined action of three refractions and two reflections, without following the light beyond one internal reflection, is sufficiently complex, and has been analysed in the following manner by Sir David Brewster.

He took a plate of glass of the form MN, fig. 142, having an oblique face M*d* cut upon one of its ends.

Fig. 142.



"A ray of light RA, polarised + 45° and — 45°, was made to fall upon it at A, at an angle of incidence of nearly 83°, so that the inclination of the planes of polarisation of the reflected ray AP was about 36½°. Now the ray AC, after reflection in the direction CS, without any refraction at B, where it emerges perpendicularly to M*d*, would also have had the inclination of its planes of polarisation equal to 36½° if there had been no intermediate refraction at A; but this refraction alone being capable of producing an inclination of 53°, or a rotation of 53° — 45° = 8°, and this rotation being in an opposite direction from that produced by the second reflection at C, the inclination of the planes of polarisation for the ray CS is nearly 44½°, the reflection of C having brought back the ray AC almost exactly into the state of natural light.

"Without changing either the light or the angle, I cemented a prism M*cd* on the face M*d*, so that *cd* was parallel to *d*N, and I found that the second refraction at *b*, equal to that at A, changed the inclination of the planes of polarisation to 53°; that is, the two refractive actions at A and *b* had overcome the action of reflection at C, and the pencil *bs* actually contained light polarised perpendicular to the plane of reflection.

"In order to put this result to another test, I took a plate M*c* NQ (fig. 142) of the same glass, which separated the pencil *bs* reflected at the second surface, from the parallel pencil AP reflected from the first surface, and I found, that at an angle of 83°, the value of the inclination I or φ for the ray was about 37½°, while the value of I for the ray *bs* was nearly 55°, an effect almost equal to the refractive action of a plate at 83° of incidence.

"When the pencil RA is incident on the first surface at the polarising angle or 56° 45′, the rotation produced by refraction at A is about 2°, or the inclination I = 45° + 2° = 47°; but the maximum action of the polarising force at C is sufficient to make I = 0° whether x is 45° or 47°. Hence CB is completely polarised in the plane of reflection, and the refractive action at *b* is incapable of changing the plane of polarisation when I = 0°; the reason is, therefore, obvious why the two rotations at A and *b*, of 2° each, produce no effect at the maximum polarising angle.

"If we now call

φ = inclination to the plane of reflection produced by the first refraction at A,

φ' = inclination produced by the reflection at C,

φ'' = inclination produced by the second refraction at *b*,

We shall have

Polarisation.

$$\cot.\varphi = \cos.(i - i'), \text{ or } \tan.\varphi = \frac{1}{\cos.(i-i')},$$

$$\tan.\varphi' = \tan.x\,\frac{\cos.(i+i')}{\cos.(i-i')} = \frac{\cos.(i+i')}{(\cos.(i-i'))^2},$$

$$\cot.\varphi'' = \cot.x\,(\cos.(i-i')) = \frac{(\cos.(i-i'))^3}{\cos.(i+i')}$$

"These formulæ are suited to common light, where x = 45°, but when x varies they become

$$\cot.\varphi = \cot.x\,(\cos.(i-i')),$$

$$\tan.\varphi' = \tan.x\left(\frac{\cos.(i+i')}{(\cos.(i-i'))^2}\right),$$

$$\cot.\varphi'' = (\cot.x\left(\frac{(\cos.(i-i'))^3}{\cos.(i+i')}\right).$$

"Resuming the formula for common light, viz. $\cot.\varphi' = \frac{(\cos.(i-i'))^3}{\cos.(i+i')}$, it is obvious that when $(\cos.(i-i'))^3 = \cos.(i+i')$, $\cot.\varphi'' = 1$, and $\varphi'' = 45°$; that is, the light is restored to common light.

"In glass where m = 1·525 this effect takes place at 78° 7′, a little below 78° in diamond, and a little above 80° in water.

"At an angle below this φ becomes less than 45°, and the pencil contains light polarised in the plane of reflection; while at all greater angles φ is above 45°, and the pencil contains light polarised perpendicular to the plane of reflection. Hence we obtain the following curious law:

"'*A pencil of light reflected from the second surfaces of transparent plates, and reaching the eye after two refractions and an intermediate reflection, contains, at all angles of incidence, from* 0° *to the maximum polarising angle, a portion of light polarised in the plane of reflection. Above the polarising angle the part of the pencil polarised in the plane of reflection diminishes till* $\cos.(i+i') = (\cos.i - i'))^3$, *when it disappears, and the whole pencil has the character of common light. Above this last angle the pencil contains a quantity of light polarised perpendicular to the plane of reflection, which increases to a maximum and then diminishes to zero at* 90°.'

"Let us now examine the state of the pencil CS′ after only one refraction and one reflection. Resuming the formula $\tan.\varphi' = \frac{\cos.(i+i')}{(\cos.(i-i'))^2}$, it is evident that when $(\cos.(i-i'))^2 = \cos.(i+i')$, $\varphi' = 45°$, and the light restored to common light. This takes place in glass at an angle of 82° 44′. At all angles beneath this the pencil contains light polarised in the plane of reflection; but at all angles above it, the pencil contains light polarised perpendicular to the plane of reflection, the quantity increasing from 82° 44′ to its maximum, and returning to its minimum at 90°.

"Let us now apply the results of the preceding analysis to M. Arago's experiment. Suppose the angle of incidence to be 78° 7′, and let the light polarised by reflection at A (fig. 142) be = m, and that polarised by one reflection also = m. Then, since the pencil *bs* is common light, the polarised light in the whole reflected pencil AP, *bs*, is = m, whereas the light polarised by the two refractions is = 2m; so that the experiment makes two quantities appear equal when the one is double that of the other. If the angle exceeds 78° 7′, the oppositely polarised light in the pencil *bs* will neutralise a portion of the polarised light in the pencil AP, and the ratio of the oppositely polarised rays which seem to be compensated in the experiment may be that of 3m or even 4m to 1.

"We may now obtain formulæ for computing the exact quantities of polarised light at any angle of incidence, either in the pencil CBS or *bs*.

Polarisation.

"The primitive ray RA being common light, AC will not be in that state, but will have its planes of polarisation turned round a quantity x by the refraction at A; so that cot. x = cos. $(i - i')$. Hence we must adopt for the measure of the light reflected at C the formula of Fresnel for polarised light whose plane of incidence forms an angle x with the plane of reflection. The intensity of AC being known from the formula for common light, we shall call it unity, then the intensity I of the two pencils polarised $-x$ and $+x$ to the plane of reflection will be

$$I = \frac{\sin.^2 (i-i')}{\sin.^2 (i+i')} \cos.^2 x + \frac{\tan.^2 (i-i')}{\tan.^2 (i+i')} \sin.^2 x, \text{ and}$$

$$Q = I\left(1 - 2\frac{\left(\frac{\cos.(i+i')}{(\cos.(i-i'))^2}\right)^2}{+1\left(\frac{\cos.(i+i')}{(\cos.(i-i'))^2}\right)}\right)$$

"In like manner, if the intensity of CB = 1, we have

$$\tan. x = \frac{\cos.(i+i')}{(\cos.(i-i'))^2},$$

and the intensity I of the transmitted pencil *bs*

$$I = 1 - \frac{\sin.^2 (i-i')}{\sin.^2 (i+i')} \cos.^2 x + \frac{\tan.^2 (i-i')}{\tan.^2 (i+i')} \sin.^2 x \text{ and}$$

$$Q = \left(I\,1 - 2\frac{\left(\frac{(\cos.(i-i'))^3}{\cos.(i+i')}\right)^2}{1+\left(\frac{(\cos.(i-i'))^3}{\cos.(i+i')}\right)^2}\right)$$

"The following table, computed from the formulæ in the preceding page, shows the state of the planes of polarisation of the three rays AC, CS, and *bs*.

Angle of Incidence on the First Surface.	Angle of Refraction at First Surface, and Angle of Incidence on Second Surface.	Inclination of Plane of Polarisation of AC, fig. 142.	Inclination of Plane of Polarisation of CS, fig. 142.	Inclination of Plane of Polarisation of *bs*, fig. 142.
0° 0′	0° 0′	45° 0′	45° 0′	45° 0′
32 0	20 33	45 34	32 20	32 51
40 0	25 10	45 58	24 12	24 56
45 0	27 55	46 17	17 49	18 38
56 30	33 30	47 22	0 0	0 0
67 0	37 34	48 57	18 20	20 50
70 0	38 30	49 33	23 34	27 6
75 0	39 46	50 45	32 22	37 48
78 37	40 29	51 49	38 10	44 59
79 0	40 33	51 56	38 49	45 46
80 0	40 42	52 16	40 27	47 46
83 0	41 5	53 21	44 39	53 40
86 30	41 23	54 47	50 58	60 13
90 0	41 58	56 29	56 29	66 19

SECT. VI.—*On the Polarisation of Light by Absorption and Dispersion.*

In the preceding section we have considered common light as consisting of two pencils of polarised light, having their planes of polarisation at right angles to each other. The very same results would take place if we considered a beam of light as consisting of two sets of polarised rays, all those of one set having their planes of polarisation in every possible direction, and of another set having their planes of polarisation at right angles to those of the former.[1] In this view of the subject, common light is polarised when it issues from the luminous body, and when we polarise it or decompose it by double refraction, or polarise it completely by reflection or refraction, we merely separate the one half of it polarised + from the half polarised —. This effect is analogous to the decomposition of white light into its colours. All the colours exist in the sun's light, and they are merely separated by prismatic refraction, or by interference, or by absorption.

Polarisation.

Now common light may also be decomposed by dispersion and absorption; that is, if we can contrive any method of dispersing or absorbing *one of the two polarised pencils* of common light, we shall exhibit the other pencil in its state of natural polarisation.

Crystals in which this effect is produced are called singly polarising or singly refracting crystals. They were first observed and described by Sir David Brewster in the year 1812.[2] The first mineral in which he discovered this property was the agate, in which one of the pencils is dispersed into a nebulous mass of light, sometimes of the form of a crescent, so that the bright image was all polarised in one plane, like one of the pencils of Iceland spar. The mass of nebulous light, too, was always polarised in a plane perpendicular to that of the bright image.

The same author discovered a similar property in certain specimens of the carbonate of barytes, which exhibited several interesting phenomena,[3] in thick crystals of mica,[4] and in mother of pearl,[5] and very curiously in oil of mace,[6] and other substances. The same property he found in various artificial crystals, but particularly in nitre.

Another very beautiful example of polarised nebulous images was observed by the same author in an artificial kind of nacre already referred to, in which there are three nebulous polarised images, with a bright image enclosed in the middle one of the three nebulous images.[7]

A similar property was discovered in 1815 in the *tourmaline*, nearly about the same time, by M. Biot and M. Seebeck, the priority belonging to the former. This crystal has double refraction, like all other crystals of the same class; but when it is cut by planes passing through the axis of the crystal, and has a certain thickness (about the twenty-fifth of an inch, but which varies in different specimens), it transmits only one of the pencils formed by double refraction. The pencil polarised in the plane of the principal section is absorbed, or somehow or other lost, while the one depolarised at right angles to that section is transmitted. If we take two such plates of tourmaline, and place them with their axes parallel, the unabsorbed pencil will be freely transmitted through both; but if we begin to turn one of them round, the light will become fainter and fainter, and the luminous object will vanish entirely when the axes are at right angles to each other. By continuing to turn, the image again appears, reaches its maximum when the axes are parallel, and then vanishes when the axes are at right angles. The same phenomenon is exhibited by the *agate* in reference to its distinct image.

In all the singly refracting and polarising crystals above enumerated, the effects described arise from a certain degree of imperfection in the structure and combination of the elementary crystals, by which one of the polarised pencils is reflected or absorbed; but Sir David Brewster found that the same property may be communicated to any crystal, *merely by altering its superficial conformation.*

If we take a hexahedral prism of *nitrate of potash*, and

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[1] Phil. Trans. 1815, p. 149. *Ibid.* 1830, p. 84.
[2] Treatise on New Philosophical Instruments, p. 329. See also Phil. Trans. 1813, p. 101. *Ibid.* 1814, p. 188.
[3] Edinburgh Transactions, vol. vii. p. 289.
[4] Phil. Trans. 1814, p. 225.
[5] Phil. Trans. 1814.
[6] *Ibid.* p. 27 and 38.
[7] Phil. Trans. 1836, p. 53.

Polarisation.

observe a luminous object through two of its inclined surfaces that have a good natural or artificial polish, we shall perceive two distinct and perfectly formed images. If we now roughen these two surfaces, and cement upon each of them a plate of glass by means of *balsam of capivi*, the character of the two images will be greatly changed. The image that has suffered the *greatest* refraction will be as *distinct* as before, but the other image will be either of a *faint reddish colour*, or wholly invisible, according to the degree of roughness induced upon the refracting surfaces. When *oil of cassia* is used instead of the balsam, the *least refracted image*, if it was visible before, will now be *completely extinguished.*

By substituting pure *alcohol*, or the *white of an egg*, instead of the balsam, the *least refracted image* will become *distinct*, and the *most refracted image* will be either a mass of *nebulous light*, or almost invisible.

In order to explain these phenomena, we must recollect that the index of refraction for the *ordinary* image of *nitre* is 1·511, and that of the *extraordinary* image 1·328. When the rough surface of the nitre is covered with balsam of capivi, which has nearly the same index of refraction as the ordinary image, the same effect is produced as if the rough surface had been polished for the ordinary rays. All the little pits or depressions in the rough surface being filled up with balsam, the ordinary rays suffer little or no refraction in penetrating the crystal, and therefore the image which they form will be as clear and distinct as in the first experiment. But since the index of refraction for the extraordinary image is much less than that of the balsam, the rays of which it is composed will not enter the crystal undisturbed, but will be scattered in the same manner as if its surface was rough, and had a refractive power corresponding to the difference between the index of refraction for the extraordinary ray, and the index of refraction for the balsam. When *water* or *alcohol* is substituted in room of the *balsam*, the effects now described are interchanged, the roughness being removed for the extraordinary rays by the application of a fluid of the same refractive density, while the rays that form the ordinary image are dispersed by the refractions which still exist at the rough surface of the crystal.

These effects will be better understood by supposing the crystal to consist of an extraordinary and an ordinary medium, arranged in alternate strata, or as water exists in wet hydrophanous opal. When the superficial polish of both these media is removed, the application of the *balsam* restores, as it were, the polish of the ordinary medium, without restoring that of the extraordinary medium; while the application of the *alcohol* restores the polish of the extraordinary medium without restoring that of the ordinary medium.

These results were repeatedly obtained with *calcareous spar*, *arragonite*, *nitre*, *carbonate of potash*, and other crystals;[1] and we have now before us a singly-polarising prism of *Iceland spar*, made nearly twenty years ago, which answers all the common purposes of a plate of tourmaline or a parcel of glass plates.

Sect. VII.—*On the Depolarisation of Light, and the Colours of thin Crystallized Plates in Polarised Light.*

The phenomena which we are about to describe are among the most splendid in optics. They were discovered by independent observation by M. Arago and Sir David Brewster; the priority of discovery belonging to M. Arago. The very same colours, indeed, as we shall presently see, had been observed by Huygens, Robison, Malus, and others, in Iceland spar; but they were not aware of their nature and origin.

Polarisation.

There are *four* methods of exhibiting these colours, which may be used at pleasure, and each of which has its advantages.

First method of showing the phenomena.

1. If we take a plate of *agate* or *tourmaline*, or any other of the artificial singly-polarising crystals already described, and having cut it into two parts, each of which is at least equal to the diameter of the pupil of the eye, though this is not absolutely requisite, fix each of them above an aperture in a piece of card or brass, so that no light passes at their edges. Let them be now placed at the distance of an inch or more, the one near the eye being capable of turning round the axis of vision; and let this last be turned into such a position that the light of the sky, or that of a flame enlarged by a lens placed near it, is no longer able to penetrate the second singly-refracting plate.

If we now introduce between the two plates of tourmaline, for example, a plate, either thick or thin, of any doubly-refracting substance, we shall observe very curious effects. If the plate is *thick*, such as one of sulphate of lime, the 30th of an inch and upwards, we shall find that the insertion of the plate has *revived*, as it were, the light which refused to pass through the second plate, and this light will be white. If we turn the sulphate of lime round, we shall find *four positions* 90° from each other, in which the revived light is a maximum; and other four bisecting these, and also 90° from each other, in which the light entirely vanishes, as before the sulphate of lime had been introduced.

This property of reviving the light has been called the *depolarisation of light*, because the sulphate of lime deprives the rays polarised by the first plate, of that kind of polarisation which prevented them from penetrating the second plate.

But if the plate is thin, between the fiftieth and the seventy-fifth of an inch, we shall have precisely the same phenomena, with this difference only, that the restored light is brilliantly coloured. The colours vary in intensity, like the white light, disappearing in the positions 0°, 90°, 180°, and 270°, and reaching their maximum at 45°, 135°, 225°, and 315°. If we now turn the plate of tourmaline next the eye round 90°, so that the axis of the two plates are parallel, and the pencil polarised by the first freely transmitted by the second, and if we then introduce the same plate of sulphate of lime as before, we shall now find that in the *four* positions of it, viz. 0°, 90°, 180°, and 270°, where no light or colours were formerly, nothing but white light is visible; but that at the positions 45°, 135°, 225°, and 315°, where the maxima of light and colour took place, we have the maxima of a colour *complementary* to that formerly seen, the intensity of this colour gradually increasing from nothing at 0°, reaching its maximum at 45°, again diminishing to 90°, and so on with the other quadrants. These colours are called the *colours of crystallized plates, or the colours of polarised light.*

In the preceding experiment with plates of tourmaline, we see only one of the two complementary colours, while the position of the tourmaline remains the same. The disadvantage of using the tourmalines is, that, from their brown colour, the brilliancy of the polarised colours is greatly injured; and the tourmalines therefore cannot be employed, either when we wish to have the most brilliant representations of the phenomena, or when it is necessary to study the exact tints which are developed.

But if we use the plates of *agate* or of roughened Ice-

[1] Phil. Trans. 1819, p. 146.

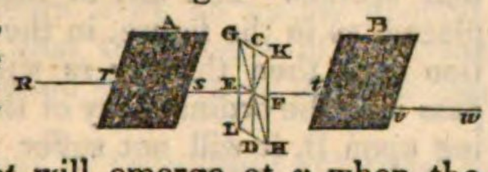
Polarisation.

land spar in the same manner, we shall not only have identically the same phenomena of colour in the bright and distinct image formed by the agate with a purer light; but we shall have the additional phenomenon of this bright coloured image placed in the middle of a *nebula* or haze of the *complementary* colour, so that we here see both the colours at the same time, and without any of the superadded brown colour imparted by the tourmaline. If the colour of the distinct image is *green*, it will be encircled by a haze of *red* light; if it is *blue*, with a haze of *orange* light; and so on.[1]

Second method.

2. The *second* method consists in placing the film of *sulphate of lime* GKHL between two bundles of glass plates A and B, which polarise the light by *refraction*, as shown in the annexed figure. A ray R*r* emerges from A, polarised as at *st*, and will freely penetrate the second bundle B, and emerge, as shown at *vw*, when the planes of refraction of A and B are parallel, as in the figure; but not a ray of *st* will emerge at *v* when the planes of refraction are perpendicular to each other. When we interpose, therefore, the sulphate of lime GKHL, it will exhibit *identically* the same phenomena as between the tourmaline plates, the bundle A corresponding to the fixed plate, and B to the moveable one, and the planes of refraction corresponding to the axes of the tourmaline. If we suppose the bundles A and B to be placed with their planes of refraction perpendicular to each other, then the position of the plate of sulphate of lime, in which no colour appears, is, when its axis of double refraction CD is its principal axis (viz. the line bisecting the resultant axis) if it is biaxal, *parallel* or *perpendicular* to the planes of refraction. When CD, therefore, or EF (perpendicular to it), is in the plane of refraction of A, or *the plane of primitive polarisation*, as it is called, not a ray of coloured light reaches the eye at *v*, and hence these have been called the *neutral axes* of the plate of sulphate of lime, because they produce no change upon the ray *st*. On the other hand, when the lines GH, KL, perpendicular to each other, and inclined forty-five degrees to the *neutral axes*, are in the plane of primitive polarisation, the coloured light depolarised is a maximum, and hence they have been called the *depolarising axes* of the plate GKHL, names which will be found very convenient in the description of phenomena.

Fig. 143.

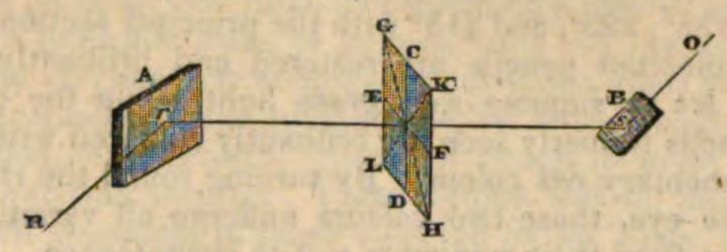


It is an interesting fact, which was discovered by Sir David Brewster, that nature actually presents us, in the case of certain crystals of *nitre*, with the whole of the apparatus in the space of half an inch. One part of the crystal has its laminæ inclined like the bundle A, while another part has them lying in a rectangular direction like B; so that such a crystal, by merely looking through it when the opposite faces are either polished by art or by a cement, exhibits its own coloured rings. Sir John Herschel subsequently observed the same fact in carbonate of potash, and proposes to call such crystals *idiocyclophanous*, or *those which show their own rings*.

Third method.

3. The *third* method is shown in the annexed figure, where A is a plate of black glass (or a bundle of 8 or 12 plates of thin transparent glass, for the purpose of increasing the light), which polarises in a horizontal plane a ray R*r*, incident at an angle of 56°, reflecting it polarised in the direction *rs*, where it is received upon a second plate of black glass B at the same angle of 56°, so

Fig. 144.



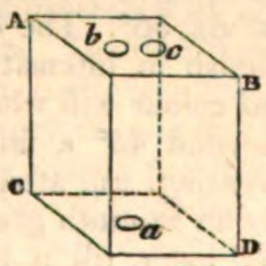
as to reflect it to the eye at O. If the plane of reflection from B is vertical, so as to be perpendicular to that from A, not a ray of the pencil R*r* will be reflected, but the eye at O will perceive a large black spot on the part of the sky or other luminous surface from which the ray R*r* proceeds.[2] The plate or plates at A are called the *polarising plates*, and that at B the *analysing plate*.

The plate of sulphate of lime is then placed at GKHL, anywhere between the plates, and it will exhibit the very same phenomena as between the tourmalines and the bundles of plates, though with more brilliancy and distinctness, as there is no brown colour to disturb the tints, and no haziness, as happens with the second bundle B of plates of glass. In this method the planes of reflection perform the same part as the axis of tourmaline and the planes of refraction in the other cases.

Fourth method.

4. The *last* method which we shall mention, is to employ rhombs of Iceland spar, both for polarising and analysing the light. If the Iceland spar is converted into two of Nicol's prisms, then each prism performs exactly the same part as the tourmaline and the reflectors, exhibiting only one of the complementary colours. This ingenious contrivance, which derives its name from its inventor, William Nicol, Esq. of Edinburgh, consists of two pieces of calcareous spar cemented together so as to transmit only one of the polarised pencils; but the difficulty and expense of constructing it well, and the risk of a change in the state of the cement which unites the two parts, render it desirable to have a simple, a cheap, and a durable substitute for it. The polariser and analyser used by Sir David Brewster in many of his experiments in elliptical polarisation, and in the action of crystallized surfaces, was a *single* rhomb of calcareous spar, having thin plates of colourless glass cemented to its natural surfaces by Canada balsam, which, while it removes any imperfection of surface, protects the surfaces from any accidental injury, or from the deterioration of the polish arising from frequently cleaning them. This rhomb, shown at ABCD, may be of any thickness suited to the diameter of the pencil of light which we wish to have. By a rhomb one inch thick we can obtain a pencil of light 0·115 of an inch in diameter; by placing an aperture of that diameter at *a* on the lower side CD, we obtain two pencils *b*, *c*, polarised in opposite planes, and just touching each other. If we wish to use only one pencil, we can conceal *b* or *c* with a wafer, and use the other; but for the purpose of our present experiment they may both be left clear. If we now construct an exactly similar, or a larger rhomb, without any aperture upon it, and place the two as we did the tourmaline plates, or in any of the positions shown in fig. 130, we shall see only *two* images, the other two being evanescent. Let the plate of sulphate of lime be now interposed as formerly, and we shall find, that when its principal axis CD forms angles of 0°, 90°, 180°, and 270° with the plane of the principal section of the rhombs, no

Fig. 145.



[1] We would recommend it to Mr Watkins to prepare this apparatus with the same ingenuity with which he has done the other apparatus for exhibiting the other phenomena of polarised light.

[2] The appearance of this black spot shows that the two reflectors are properly adjusted, so as to save all the trouble of attending to the angles at which the rays are incident on the two reflectors A and B.

Polarisation.

light is depolarised; but that when the axis forms angles of 45°, 135°, 225°, and 315° with the principal section, the *two* evanescent pencils are restored and brilliantly coloured, let us suppose with *green* light, while the other two pencils formerly seen are brilliantly coloured with the complementary *red* colour. By turning round the rhomb next the eye, these two colours undergo all varieties of intensity, from their maximum tint to evanescence.

If we now enlarge the aperture *a*, fig. 145, in the first rhomb, so that the two images *b*, *c*, in place of being in contact, overlap each other, we shall have the parts that do not overlap exhibiting the two complementary colours as before, while the parts that do overlap form *perfectly white light;* thus proving that the two colours are exactly complementary to each other. Any of the images *b*, *c* may be enlarged, if necessary, by a convex lens placed before them, or by other means.

In order to obtain a large pencil of polarised light *b* or *c*, we must make the rhomb very thick; but there is another way in which we may obtain the same effect in thin rhombs. There are particular specimens of the spar which are interrupted with veins, and which will be described in a separate section. If we obtain one of these in which the vein has a certain thickness, it will produce polarised images on each side of *b* and *c*, and these images will be perfectly *white*. We may therefore use a much larger aperture *a*, and obtain a very effective apparatus. This, however, will be better understood afterwards.

When the *veins* above mentioned are *thin*, these lateral images are beautifully coloured, the colours being portions of the coloured rings produced by the thin vein, the prism in front of the vein polarising the light, and the prism behind it analysing it.

These different methods of exhibiting the colours of crystalline plates may be varied, if we use a plate of glass as the polariser, and a tourmaline for the analyser; or, in short, we may use one half of each apparatus with one half of the other. When we wish to have a large surface of polarised light, the best and readiest is a large surface covered with black varnish.

In the preceding observations, with the *four* different kinds of apparatus, we have supposed the polariser and analyser to be fixed, either with their similar planes parallel or perpendicular to each other, and the plate of sulphate of lime to be moved round its axis. Let us suppose, however, that the sulphate of lime is *fixed* in the position where its colour, *bright red*, for example, is a maximum; that is, where any of the depolarising axes GH or KL, fig. 144, is parallel or perpendicular to the plane R*rs* of primitive polarisation. In this position of GH, let the analysing plate B be made to revolve round the ray *rs*, its motion commencing at 0°, and always keeping the same inclination to *rs*, viz. 56°. The *bright red* visible at 0° will gradually diminish in intensity as B moves from 0° to 45°, when the *red* colour will wholly vanish, and the black spot be seen. Beyond 45° a faint *green* tint will appear, gradually increasing, and attaining its maximum of brightness at 90°. At an azimuth greater than 90°, the green becomes paler and paler, till it vanishes wholly at 135°. Here the *red* again begins, and reaches its maximum brightness at 180°. Similar changes take place while the plate B moves from 180° to its original position at 360° or 0°. Hence it appears, that when the sulphate of lime alone revolves, only one of the complementary colours is visible, whereas, when the plate B only revolves, both the complementary colours are visible during each half of its revolution.

When these experiments are repeated with plates of sulphate of lime, or any other mineral having different thicknesses, different colours will be produced, varying with the thickness; and in every case the two colours which are produced, either when we use the two polarising rhombs, or cause the reflector B to revolve, are always *complementary* to each other, or together make white light.

Polarisation.

If we remove the plate B, and look through the sulphate of lime, we shall find that the light which it transmits is always white, whatever be the position of the sulphate of lime, whatever be the inclination which the ray R*r* forms with the polariser A, and whatever be the condition of the polariser itself. The decomposition of the white light, therefore, or its separation into two complementary colours, must be effected by reflection from the plate B. Now sulphate of lime is a doubly refracting crystal, giving two oppositely polarised images, lying above one another, and one of its neutral axes CD is the section of a plane passing through its principal axis of double refraction, while EF is the section of a plane perpendicular to that section. Let any of these planes, suppose EF, be placed, as in the figure, in the plane of primitive polarisation R*rs*, then the ray *rs* will not be doubled, but will pass into the ordinary ray of the sulphate of lime, and falling upon B, it will not suffer reflection. The very same will happen if CD is brought into the plane of primitive polarisation, so that in these two positions none of the light transmitted through the sulphate of lime will suffer reflection at B, and reach the eye at O. In all other positions, however, of the sulphate of lime, it forms *two* images or pencils of different intensities; and when either of the depolarising axes GH or KL is in the plane of primitive polarisation R*rs*, these two images or pencils will be of equal intensity, and polarised in opposite planes. Now, one of *these* images is *red*, and the other *green*, a fact which will be afterwards explained; and as the *red* is polarised in the plane of primitive polarisation, it will not suffer reflection from B; while the *green*, being polarised in the plane of reflection from B, will be reflected to the eye at O, and is therefore seen alone. From the same cause, when B is turned round 90°, the *green* will not suffer reflection from it; while the red will suffer reflection, and be seen by the eye at O. The plate B has therefore analysed the compound beam of *red* and *green* light by reflecting one and transmitting the other colour.

Now, if the sulphate of lime had been thicker than the fiftieth of an inch, the two pencils would have been both white; and when the plate was moved round, we should have had a white pencil reflected from B, and undergoing the very same changes that the coloured one did. Hence we see the cause of the *depolarisation of light*, both when the depolarising plate is thick and thin.

In the preceding experiments, the sulphate of lime has been supposed to be so thin as to give a *red* and a *green* tint; but if the plate is only 0·00046 of an English inch thick, it will depolarise no light at all, either coloured or uncoloured, and the black spot will be seen in every position of the sulphate of lime. If the thickness of the plate is 0·00124 of an inch, the light depolarised will be the *white*, the first order of Newton's scale, whose complementary colour is a deep *violet;* and if the plate is 0·01818 of an inch, or upwards, it will also polarise white light, composed of all the colours of the spectrum. When the plates of the mineral have an intermediate thickness between 0·00124 and 0·01818, they will give, at successive thicknesses, all the intermediate colours in Newton's table, between the white of the first order, and the white compounded of all the colours. The colours from the plate B will be those in col. 2 of Newton's table, while the colours seen in turning round the plate B will be the complementary ones in col. 3 of the same table, the one corresponding to the *reflected* and the other to the *transmitted* tints of thin plates.

By a variety of accurate experiments, M. Biot pointed out the connection between the colours of polarised light

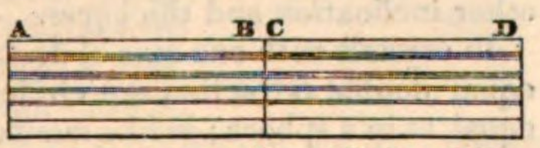
Polarisation.

and of thin plates; and in the case of sulphate of lime, the films of which he measured with an ingenious instrument invented by M. Cauchoix, called the spherometer, he has proved that the thicknesses which produce the different colours in Newton's table are proportional to the value of the tints in the last column of Newton's table for glass; this substance having nearly the same refractive power as sulphate of lime. If we wish, for example, to know the thickness of sulphate of lime which will give the *red* of the first order of colours, the number in the last column opposite red is 5⅘ths; then, since the *white* of the *first* order is produced by a plate 0·00124 of an inch thick, the number opposite which is 3⅘ths, we say, as 3⅘ths is to 5⅘ths, so is 0·00124 to 0·00211, which is the thickness at which sulphate of lime depolarises the *red* of the first order. By reversing this rule we can determine the colour which will be depolarised at any given thickness. This law of the colours is by no means general, and we shall presently see that the colours of polarised light bear frequently no relation whatever to those of thin plates.

Popular experiments.

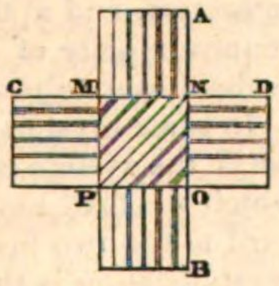
The above phenomena may be beautifully exhibited to the eye by combining pieces of sulphate of lime into a painted Gothic window, so that when the window is exposed to common or to polarised light it appears perfectly colourless, but when seen by reflection, it will exhibit all the splendid colours of the separate films. Though this experiment is well suited for exhibition, yet the following one, which was also made by Sir David Brewster, is more instructive. Selecting an uniform plate of sulphate of lime, about the twenty-fifth of an inch thick, he ground down,[1] with the powder of schistus, one of its faces, so as to make it a sort of wedge, in which the thickness varies from the twenty-fifth of an inch down to the thinnest edge that could be made. The plate was then placed in water, which acted upon it slowly, making its edge thinner, and giving a slight polish to its surface. When this film is placed at GH, in fig. 144, its figure will be seen covered with coloured fringes, as in fig. 146, parallel to its edges. At its thinnest edge the colours of the first order will commence from *black*, and gradually increasing, as in Newton's table, till, at the thick edge AD, we have the sixth or seventh, or higher orders of colours. Here we see at once how all the different tints and different orders are connected with the different thicknesses of the plate.

Fig. 146.



If we now cut this plate into two equal parts AB, CD, and cross them as in the figure, a *new set of fringes* will appear, parallel to a line joining the points where the two thinnest and the two thickest edges intersect, that is, parallel to NP, one of the diagonals of the intersectional square MNOP. The line NP will be black, and from NP to M and N the fringes will be exactly the same as those from the thin to the thick edge of the plate.

Fig. 147.



If the plates *ab*, *cd* have their axes at right angles to each other, there will be only one set of fringes, beginning at the angle where the two tints are minimum.

If we grind one side of the plate spherical, so that the thickness shall vary like the plate of air between a convex and a plane surface, then, by combining a plate of this kind with a prismatic plate, or by combining two similar plates, and by varying their maximum thicknesses, their breadths, &c. we shall produce, by their parallel or rectangular combination, intersectional fringes of figures of great variety and extreme beauty. These figures will be analogous, *mutatis mutandis*, to those observed by Mr Knox, and the far more splendid exhibitions produced by crossing plates of glass in the manner described in a subsequent chapter.

If we grind *concave* surfaces on one of the faces of the crystalline plate, we shall have circular rings, equidistant if the concavity is conical, but resembling those of thin plates if it is spherical. These plates may also be combined with those which give circular and rectilineal fringes, and very fine effects produced by the combination.[2] Still more remarkable effects may be produced by turning beautiful patterns upon the sulphate of zinc, or etching them either by the action of pure *water*, or water slightly acidified. Lines of equal depths will be all equally coloured, and the slightest differences in depth, which can be easily regulated by a fine turning-lathe, will produce a great variety of different colours. Coloured figures and landscapes may be executed by scraping away the surface to the thickness necessary to produce the requisite tints. A cipher, too, might be executed upon a mineral; and if we cover the surface upon which it is formed with a fluid of the same refractive power, it will be absolutely illegible by common light, but may be distinctly deciphered when placed between the polarising and analysing plates.

A sheet of ice irregularly frozen, and held in the position just mentioned, exhibits the colours of crystallized plates in a splendid manner; but if in a severe winter, when ice can be handled without melting, we take an uniform plate, and dissolve a pattern upon it by heat, which may be applied in many ways, so as to affect only the parts to be made thinner, we shall observe a phenomenon than which nothing can be more splendid.

Sect. VIII.—*On the System of Rings produced by Uniaxal Crystals.*

Rings in uniaxal crystals.

In the preceding experiments the crystallized plate is held at such a distance from the polarising plate that its surface could be distinctly seen by the eye; and it was from observations made in this manner that M. Biot deduced his empirical formulæ for expressing the variation of the tint, as depending on the thickness of the crystallized plate, and on the square of the sine of the inclination of the refracted ray to the axis of the crystal.

From this mode of observation M. Biot concluded, that *arragonite*, *topaz*, *sulphate of lime*, *felspar*, *sulphate of barytes*, *and sulphate of strontian*, were all crystals with one axis of polarisation and double refraction. In 1813, however, Sir David Brewster was led to an entirely different mode of observation. He brought the crystal or plate as close to his eye as possible, and by using a large polarising plate, such as a black japanned tray, he was able to see, *at the same instant*, the colours produced at various angles of inclination, in place of determining the loci of these colours, as was done in the old way, by a great number of insulated observations.

When, for example, he looked through the *ruby*, the *emerald*, *topaz*, *ice*, *nitre*, and other bodies, he observed the most beautiful system of rings when the polarised light

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[1] The plate may be cemented by one of its faces to a piece of plate-glass, which will protect it from breaking, and after it is finished and bisected, each half should be enclosed between two glass plates.

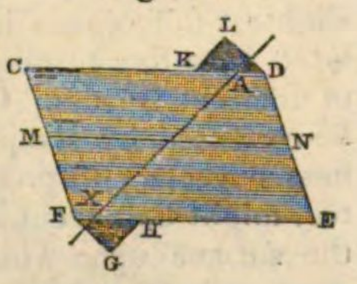
[2] We would recommend to the practical optician the construction of such plates as a matter of trade.

Polarisation.

passed along the axis of double refraction of these bodies. The rings in crystals with one axis are essentially different from those with two axes.

The *uniaxal system of rings* is represented in Plate CCCLXXXIII. fig. 29, 30. I discovered them in all the doubly refracting crystals with one axis, already mentioned, excepting in Iceland spar, in which they were first observed by Dr Wollaston, and independently by M. Biot and Dr Seebeck. This system of rings is seen along the axis of double refraction; and it has been customary to cut faces upon the obtuse angles of the rhomb of calcareous spar perpendicular to the axis, in order to see them. Sir David Brewster, however, employed the simple method shown in the annexed figure, which does not require the aid of the lapidary. Let CDEF be the principal section of a rhomb of Iceland spar; cement upon CD and EF two small prisms DLK, FGH, having the angles LDK, GFH about 45° each; and let this rhomb be placed between the polarising and analysing plates, so that the polarised ray *rs* passes perpendicularly through the faces LD, FG. The rhomb must be held as close as possible to the reflector B, which need not be larger than the pupil of the eye. When the black spot is seen on the reflector B, in the apparatus as adjusted, then, when the rhomb is interposed, the observer, with his eye close to the plate B, and looking, as it were, through the reflected image of the rhomb, will see the beautiful system of rings shown in fig. 29, Plate CCCLXXXIII., intersected by a black rectangular cross AB, CD, the arms of which are parallel and perpendicular to the plane of primitive polarisation. The colours of the rings, of which seven or eight may be readily seen, are almost exactly the same as those of the reflected rings in thin plates, as seen in Newton's table or scale of colours.

Fig. 148.



If we turn the rhomb round its axis, the rings will suffer no change, the four arms of the black cross revolving round the circumference of the rings, or rather these four arms remain fixed, and the rings revolve with the rhomb.

If the rhomb is now fixed so that the rings are distinctly visible, and if we cause the plate to revolve from zero or 0°, then the rings will change into the form shown in fig. 30, Plate CCCLXXXIII., in which the black cross is broken up; and at 45° the rings will appear as in fig. 31, which is the *complementary system*, with a white centre exactly similar to the system seen by transmission in thin plates. These two systems of rings superposed or placed one above the other, would produce uniform white light, without any trace of rings. By continuing to turn B, the *primary system*, fig. 29, will re-appear at 90°, 180°, and 270°; and the *secondary system*, fig. 31, at 45°, 135°, 225°, and 315°; while the *intermediate system*, fig. 30, will be seen at intermediate azimuths.

It is very interesting to trace the passage of the *primary* into the *secondary* system. When B begins to turn, the arms of the black cross widen and become less black, and within them we can see segments of the *complementary* rings, whose dark intervals correspond to the bright ones of the primary rings, and *vice versa*. As B advances, the rings of the primary set grow less, and more dilute, while the others grow larger and brighter, till, at 45°, the *secondary* set is complete. When the light previous to polarisation has passed through ground glass, the diluted primary rings appear of a gray-white colour, and as if they were nearer the eye than the rest.

If, in place of the plate B, we use a polarising rhomb or an achromatised prism of Iceland spar, and look through it along the axis of the other rhomb, then, when the plane of its principal section is parallel or perpendicular to the plane of primitive polarisation, we shall see in one of its two images the *primary* system of rings, and in another the *secondary* system; and in intermediate positions we shall see the intermediate system, the one constantly passing into the other.

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When all these experiments are repeated in homogeneous light, the system of rings will be *smallest* in *violet*, and *largest* in *red light*, and of intermediate sizes in intermediate colours.

If we divide the rhomb of spar, fig. 148, into two parts by the line MN, and examine the rings through each separately, we shall find that the rings produced by each part are *larger* than those produced by the whole, the thinnest piece producing the largest rings. Hence two rhombs united will give a system of rings corresponding to those produced by one rhomb of the same magnitude.

Positive systems of rings.

The systems, if formed by *zircon*, *ice*, and positive doubly-refracting crystals, are exactly the same as the preceding. But if we unite a positive system with an equal negative system, they will destroy each other; and if the two systems are unequal, we shall have a system equal to the difference of their effects. These experiments of combining systems of positive and negative rings, though rather troublesome, are extremely interesting. When such systems are combined, and the space between the crystals that form them left open, a series of splendid changes are induced upon the resulting system, by placing one or more crystallized films in one or more azimuths between them; but we shall have occasion to return to this subject in the section on the multiplication of images by Iceland spar.

In examining the phenomena of the primary rings, it is obvious that there is no polarisation, as there is no double refraction along the axis of the crystal. The tints polarised increase with the double refraction, that is, with the inclination of the polarised ray to the axis of double refraction; and their numerical value, as given in Newton's scale, increases with the square of the sine of that inclination. At any given inclination to the axis the tint increases with the thickness through which the polarised ray passes, so that when we have determined the tint at any given inclination and thickness, it is easy to find it for another inclination and thickness.

In crystals with one axis of double refraction, the lines of equal double refraction are circles when the thickness is equal, as in a sphere; in like manner, the lines of *equal tint*, or the *isochromatic lines*, are circles, the tints being a maximum in the equator, where the inclination to the axis is 90°. In crystals with great double refraction the same tint at the same inclination to the axis is produced at a much less thickness than in crystals with feeble double refraction. Quartz, for example, has a very feeble double refraction, and at the same inclination to the axis it would require a plate of quartz 115 times as thick as a plate of Iceland spar to produce the same tint in Newton's scale.

In some crystals with one axis, such as quartz, amethyst, beryl, the system of rings is disturbed by secondary causes, which we shall have occasion to refer to more fully in regard to the two first crystals. In other crystals imperfect crystallization is the general cause of these irregularities.

In Iceland spar, zircon, ice, tourmaline, and various other minerals, the tints of the rings are very nearly those of Newton's scale; but there are other crystals, such as apophyllite, in which Sir David Brewster and Sir John Herschel discovered remarkable deviations, which will be described in a subsequent section.

The intensity of the polarising force, or the value of the tint polarised at a given thickness, has been calculated by different persons for different crystals. The following have been given by Sir John Herschel for uniaxal crystals.

Polarisation.

	Numerical Value of the highest Tint.	Thicknesses that produce the same Tint.
Iceland spar	35801	0·000028
Hydrate of strontia	1246	0·000802
Tourmaline	851	0·001175
Hyposulphate of lime	470	0·002129
Quartz	312	0·003024
Apophyllite, first variety	109	0·009150
Camphor	101	0·009856
Vesuvian	41	0·024170
Apophyllite, second variety	33	0·030374
third variety	3	0·366620

These measures are calculated for the *yellow* rays.

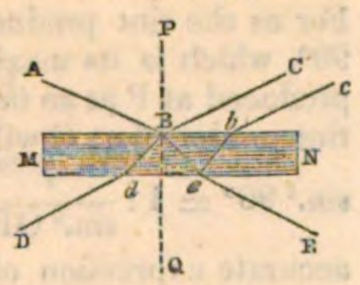
Sect. IX.—*On the System of Rings produced by Biaxal Crystals.*

Biaxal rings.

The biaxal system of rings was discovered by Sir David Brewster, while he was looking along one of the axes of *topaz* when the crystal happened to reflect the light of a part of the sky which was partially polarised, so that they were seen without the aid either of a polarising or an analysing plate.

Upon examining other minerals, he discovered that the possession of two systems of rings was the characteristic of by far the greater number of crystallized bodies. In some of the crystals, such as *topaz*, the lines along which each system of rings is seen are so much inclined to each other, that we cannot see the two systems at once; whereas in others, where the inclination of the lines is small, both the systems may be distinctly seen at the same time. This will be understood, in the case of topaz, from fig. 149, where MN is a plate of topaz with parallel faces of cleavage perpendicular to PQ, the principal axis of double refraction. If we expose this plate to polarised light, so that the polarised ray passes along the line ABeE (the plane of incidence being in one of the two neutral axes of the plate); and if the eye at A receives this ray *without* using the *analysing plate*, it will see in the direction of that ray a system of oval rings of extreme beauty, like that shown in Plate CCCLXXXIII. fig. 32. When the polarised light is transmitted along the line CB*d*D, equally inclined to the perpendicular PQ, it will see a similar system. The lines BD, Be are therefore the resultant axes of topaz, along which the double refraction vanishes. The angle ABC is about 121° 16′, but the inclination of the refracted rays or of the resultant axes is only 65°. Similar rings are seen by transmission in the direction D*d*, E*e*, but only *when the analysing plate* is used.

Fig. 149.



If we now receive the reflected ray upon the analysing plate at 0°, the system of rings will appear as in fig. 33, Plate CCCLXXXIII., which differs from fig. 32 only in the parts near the major axis. The colours are the same, but the central spots are much smaller, and the mass of darkness with which they are surrounded encroaches considerably upon the blue part of the first ring. The same system will be seen at 90°, 180°, 227°; but upon turning round the analysing plate, we shall see, at 45°, 135°, 225°, and 315°, a third set, shown in fig. 34, which is comparatively faint in its colour, but distinguished by its peculiarities. In its general structure it resembles the set in fig. 32, but in the middle of each central spot there is a darker spot, composed of blue and red chiefly, with a little green above the blue, and every ring is divided into two rings, each of which has the same colours as the original ring. This division of the rings occupies only a part of the semicircumference of each, and is not seen beyond the third ring. When the analysing plate begins to move from 0°, 70°, &c. where fig. 33 is seen, towards 45°, 135°, &c. two blue spots, and the division of the rings, begin to appear at A and A in all the rings, and in the two central spots, and move along each till they reach B at 45°, 135°, &c. Continuing to turn the analyser, the spots and divisions move onward from B to C in all the rings, &c., and disappear at C at 90°, 180°, &c. This curious system of rings is obviously the first set in fig. 32, seen at the same time with their complementary rings, and is a very rare phenomenon.

Polarisation.

Rings in nitre.

The biaxal system of rings is best seen in *nitre* or *saltpetre*, in which the inclination of the resultant axes is only about 5°, or forming an angle of $2\frac{1}{2}$ with the axis of the six-sided prism. When a plate of nitre, about the sixth or eighth of an inch thick, is placed before a small analysing plate, and very close to it, and the eye also held as close to the analysing plate as possible, we shall see the beautiful biaxal system of rings discovered by Sir David Brewster, and shown in Plate CCCLXXXIII. fig. 35, where the plane passing through the two axes of nitre is parallel or perpendicular to the plane of primitive polarisation. At angles inclined 45° to these planes, the rings assume the form shown in fig. 36. In passing from the one of these states to the other, the rings assume the forms shown in figs. 37 and 38. The colours begin at the centres A and B of each system; but at a certain distance, varying with the thickness of the plate, the rings, in place of returning and encircling each pole, encircle the two poles, as an ellipse does its foci. When the thickness of the plate is very small, the rings enlarge, and the fifth ring will surround both poles. At a less thickness the fourth, and so on, till at a very small thickness the first ring, will surround both poles, and the system then resembles much the uniaxal system of rings. If the plate of nitre is very thick, the rings diminish in size. These colours deviate more and more from those of Newton's scale, and the tints do not begin at the poles A and B, but at virtual poles in their vicinity. The colours of the rings within the two poles are *red*, and beyond them *blue*, and the great body of the rings is pink and green. The rings have been called *isochromatic lines*, or *lines of equal tint*; and the axes passing through the poles A, B, *optical axes*, or *axes of compensation*, or *resultant axes*.

We have already given a long list of the various minerals and crystals which exhibit the biaxal system of rings, and also the position of the line which bisects the angular distance between the resultant axes, which is the *principal axis* of the crystal.

The following table, showing the inclination of the resultant axes in different crystals, was drawn up from the observations of Sir David Brewster. Several observations by other observers have been added.

Names of Minerals.	Character of Principal Axis.	Inclination of Resultant Axis.
Glauberite	Negative	2° or 3° 0′
Sulphate of nickel, certain specimens	Positive	3 0
Carbonate of strontites	Negative	6 56
——— barytes	Ditto	...
Nitrate of potash	Ditto	5 20
Mica, certain specimens	Ditto	6 0
Talc	Ditto	7 24
Carbonate of lead	Ditto	10 35
Sulphato-carbonate of lead	Ditto	10 30
Mother-of-pearl	Ditto	11 28
Hydrate of barytes	Ditto	13 18
Mica, certain specimens, about	Ditto	14 0
Arragonite	Ditto	18 18

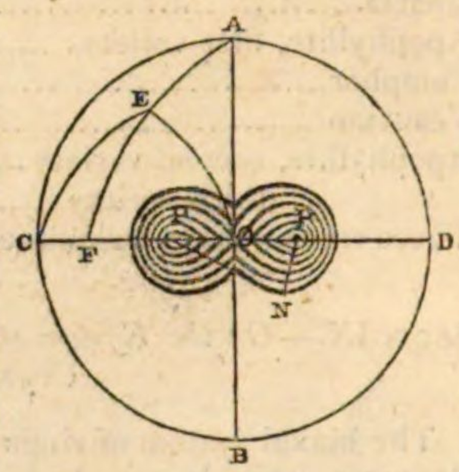
Polarisation.

Names of Minerals.	Character of Principal Axis.	Inclination of Resultant Axis.
Pyroxene (Miller)		19° 30′
Prussiate of potash, certain specimens	Positive	19 34
Cymophane	Ditto	27 51
Borax	Ditto	28 42
Anhydrite[1]	Ditto	28 7
Mica (Biot)		30 to 37 0
Apophyllite, *biaxal*	Negative	35 8
Sulphate of magnesia	Ditto	37 24
——— barytes	Positive	37 42
Spermaceti, about	Ditto	37 40
Tincal, or native borax	Negative	38 48
Nitrate of zinc, estimated at about		40 0
Stilbite	Positive	41 42
Sulphate of nickel	Ditto	42 4
Tartrate of ammonia (Miller)	Negative	42 20
——— (Herschel)		45 0
Carbonate of ammonia	Negative	43 24
Anhydrite (Biot)		44 41
——— (Herschel)		43 48
Mica	Negative	45 0
Lepidolite	Ditto	45 0
Benzoate of ammonia	Positive	45 8
Sulphate of zinc	Negative	44 28
——— magnesia and soda	Positive	46 49
Hopeite	Negative	48 0
Brazilian topaz	Positive	49 50
Sulphate of ammonia	Ditto	49 or 42 0
Sugar	Negative	50 0
Sulphate of strontites	Positive	50 0
Murio-sulphate of magnesia and iron	Negative	51 16
Sulphate of ammonia and magnesia	Positive	51 22
Heulandite (Herschel)		54 17
Phosphate of soda	Negative	55 20
Comptonite	Positive	56 6
Felspar	Negative	58 30
Sulphate of lime	Positive	60 0
Oxynitrate of silver	Ditto	62 16
Dichroite or iolite	Negative	60 50
Topaz (Aberdeenshire)	Positive	65 0
Sulphate of potash	Ditto	67 0
Carbonate of soda	Negative	70 1
Acetate of lead	Ditto	70 25
Citric acid	Positive	70 29
Tartrate of potash	Negative	71 20
Benzoic acid (Miller)	Ditto	75 0
Tartaric acid	Ditto	79 0
Sulphate of oxide of iron and ammonia (Miller)		79 0
Tartrate of potash and soda	Positive	80 0
Carbonate of potash		80 30
Kyanite	Positive	81 48
Hyper-oxymuriate of potash		82 0
Muriate of copper		84 30
Epidote, about		84 19
Peridot		87 56
Crystallized Cheltenham salts		88 14
Hyposulphate of soda (Marx)		89 20
Succinic acid, estimated at about		90 0
Sulphate of iron, about		90 0

Many of the measures in the preceding table were taken with much care; but some of them were only estimated, and others will admit of correction by the use of better specimens than the author was able to procure.

In order to explain the biaxal system of rings, and to discover the law of the tints by which every point of the complex system of rings can be calculated, Sir David Brewster considered the *optic or resultant axes* P, P′ as produced by two or more rectangular axes, the principal one passing through O, and the other two at AB and CD. We shall suppose, however, the most simple case, where the axes are only *two*, viz. that at O, and another either coinciding with AB or CD, perpendicular to O. Now, if O is a *negative* axis, AB must also be *negative;* but if we take CD for the other axis, it must be *positive;* for as the axis CD compensates the *negative* axis O at P, acting in the same plane, it must be a *positive* axis, for a negative axis would have united its effect with that of O. For a similar reason, the axis at AB must be *negative*, in order to compensate the *negative* axis O in a plane at right angles to it.

Fig. 150.



Supposing, then, O and AB to be two *negative* axes, as in *mica*, let it be required to determine the system of rings which they will produce, or the *tint* at any point F. Now we may either assume the relative intensities of these axes, or, what is better, the angle formed by the two poles P, P, where the actions of the two axes are compensated, as this angle can be readily measured in any crystal. As the action of the axis AB (or the tint which it produces) at P is destroyed or compensated by the action of the axis O, or the tint which it produces, and as the tint is proportional to the square of the sine of the angle which the ray makes with the axis, it is evident that the intensity of the axis at O must be to the intensity of AB, as 1 to $\frac{1}{\sin.^2 OP}$. For as the tint produced at P by AB at an inclination of 90°, which is its maximum tint, is equal to the tint of O produced at P at an inclination equal to OP, the *maximum* tint produced at O will be found thus: Sin.^{2} OP : rad.^{2} or $\sin.^2 90° = 1 : \frac{1}{\sin.^2 OP}$. We have therefore obtained an accurate expression of the relative intensities of the two negative axes O and AB.

If we had supposed the rings to be produced by a *negative* axis O and a *positive* one CD (which would equally account for the phenomena), then the intensity of O will be to that of CD as cos.^{2} OP is to sin.^{2} OP.

From a great number of observations made at all inclinations to the resultant axes, and from accurate measurement of the projected rings, Sir David Brewster found that all the phenomena of the rings, with all their varieties of form and curvature, were represented by the following law.

The tint produced at any point of the sphere, by the joint action of two axes, is equal to the diagonal of a parallelogram whose sides represent the tints produced by each axis separately, and whose angle is double of the angle formed by the two planes passing through that point of the sphere and the respective axes.

In showing the application of this law, let it be required to find the tint produced at E, fig. 150, by the joint action of the two axes O and AB, whose relative intensities are as 1 to $\frac{1}{\sin.^2 OP}$. Through E draw three great circles AEF, CE, and OE; then let

[1] This must have been a different mineral from that examined by Biot.

Polarisation.

T = tint required at the point E;
θ = the arch between the point E and the axis O;
φ = the arch between the points E and C;
a = the tint produced separately at E by the greater axis;
b = the tint produced separately at E by the lesser axis;
ψ = the angle of the forces;
π = the angle CEF;
ω = the angle OEF;
A = the arch FO, or the angle OAF, or the *azimuth* on the great circle CPO passing through the poles P, P, or centres of the two systems of rings;
D = the arch FE, or the declination or distance of the point E from the same great circle;
ζ = half the difference of the angles at the base or at the diagonal of the parallelogram of forces.

Then we have

$$\cos.\theta = \cos.A \times \cos.D,$$
$$\varphi = 90° - D,$$
$$\cos.\omega = \frac{\tan.D}{\tan.\theta},$$
$$\cos.\pi = \frac{\tan.D}{\tan.\varphi},$$
$$2\,AEO = \psi = 2\,(180° - \omega) = 2\,\omega.$$

Since, then, the tints a, b produced at E by the axes O and AB are as the squares of the sines of the distance of E from these axes, or as sin.^{2} OE and sin.^{2} AE, and as the relative intensities of the axes are as 1 to $\frac{1}{\sin.^2 OP}$, we shall have

$$a = \sin.^2 OE, \text{ and } b = \sin.^2 AE \times \sin.^2 OP.$$

Having thus found the sides of the parallelogram of forces whose angle is ψ, the diagonal T of this parallelogram, or the *compound tint* at E, will be obtained in the following manner:

$$\text{Tan. } \zeta = \frac{a - b\tan.\frac{1}{2}\psi}{a+b}, \text{ and}$$
$$\zeta + \tfrac{1}{2}\psi = \text{greater angle at the base.}$$
$$\text{Hence } T = \frac{a\sin.\psi}{\sin.\zeta + \frac{1}{2}\psi}.$$

When $a = b$, $T = 2a\,(\cos.\pi + \omega)$.
When $a = b$ and the two axes O, and AB equal $\pi = \omega$ and
$T + 2a\,(\cos.2\pi)$.
When twice the angle formed by the planes OE, AE or
$\psi = 90°$, then $T = \sqrt{a^2 + b^2}$.
When $\psi = 180°$, $T = a - b$.
When $\varphi = 0°$ or 360°, $T = a + b$.

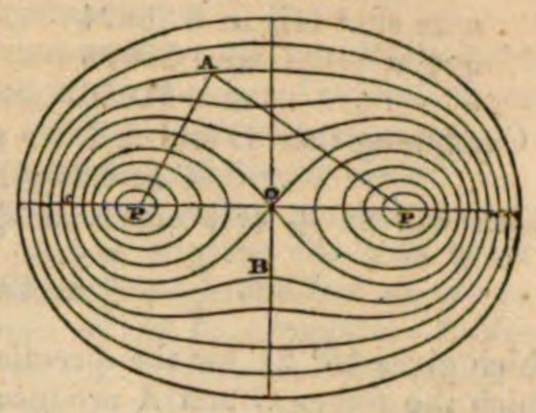
Such is the method of determining the tints, and consequently the form of the isochromatic curves in relation to the real axes to which the forces refer; but in relation to the poles P, P, the law of the tints may be more simply expressed by the formula $T = t$ sin. PE $\times$ sin. P′E, where t is the maximum tint at A, which must be previously determined. This rule was deduced by M. Biot mathematically from Sir David Brewster's law, and it was afterwards established experimentally by Sir John Herschel, without being aware of its having been deduced from the general law.

The preceding general law is equally applicable when the rings are formed in homogeneous light.

Sir John Herschel,[1] in examining the systems of biaxal rings, found that they resembled lemniscates, as represented in the annexed figure. In these curves the rectangle PE $\times$ P′E is invariable throughout each curve, and the value of this constant rectangle in any one curve is $a \times b$, b being the parameter of the curve, and a half the distance between the poles P, P. The quantity a is of course the same for each curve, but b in different curves increases in the arithmetical progression 0, 1, 2, 3, &c. for the several dark intervals of the rings, beginning at the poles, and in the progression $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$, &c. for the brightest intermediate spaces.

Polarisation.

Fig. 151.



Many interesting conclusions have been deduced from the preceding general law by Sir David Brewster. When the two *negative* axes O and AB, fig. 150, are of equal intensity, then their action will be compensated at C and D, and C D will be a single *positive* axis of double refraction, and also of an uniaxal system of rings like those in *zircon;* and the isochromatic curves given by the preceding formulæ will be circles surrounding the axis. Hence it follows, *that two negative rectangular axes of double refraction and polarisation compose a single positive axis.* If we now suppose a negative axis at CD, equal in intensity to any of the other two, it will evidently destroy the *positive* axis of compensation at CD, so that three equal and similar *negative axes in any crystal destroy each other;* and hence our author was led to the conclusion, that all the tessular crystals in which there was neither double refraction nor polarisation had three such axes. But if the *third* axis at CD is not equal to O or AB, and if O and AB are unequal, then we shall have all the phenomena of a crystal with two axes. In order to compute the tints thus produced by *three* unequal axes, let O, AB, and CD be three axes, and P, P′ the centres of the double systems of rings which they produce. We have already shown that the resulting tint of two axes O and AB, at any part E, is

$$T = \frac{a\sin.\psi}{\sin.\zeta + \frac{1}{2}\psi}.$$

In order, however, to combine this tint with another, we must know the direction of it. Since ψ is the double of the real angle of the planes in which the forces from O and AB act, the direction of the new plane in which these forces act must form an angle with the real direction of O, whose complement is

$$\frac{\frac{1}{2}\psi + \zeta}{2} \text{ or } \frac{\psi}{4} + \frac{\zeta}{2},$$

or it forms with the real direction of A an angle whose complement is

$$\frac{\frac{1}{2}\psi - \zeta}{2} \text{ or } \frac{\psi}{4} - \frac{\zeta}{2}.$$

Hence the direction of the resultant in relation to BE, the direction of the third force with which it is to be combined, is known.

In order to illustrate this in a case where the truth of the result will be immediately seen, we shall take the case of three equal axes, the general resultant of which is *nothing*. In fig. 150, let O, AB, and CD be the three equal axes, and E the point where we require to know the effect of their combined action. Take AE = 70°, CE = 60°, then EG = 30°, EF = 20°, AG = 66° 44′, OG = 23° 16′, OE = 37° 17′; then

[1] Treatise on Light, sect. 903.

Polarisation.

$a = \sin.^2 AE = 0{\cdot}883104$ $\quad \psi + \begin{cases} 237° \ 16' \\ 122° \ 54' \end{cases}$

$b = \sin.^2 CE = 0{\cdot}7500$ $\quad \zeta = 37° \ 12'$

$c = \sin.^2 OE = 0{\cdot}36694$ $\quad \omega = 40° \ 4'$

$a + c = 1{\cdot}25004$ $\quad \pi = 77° \ 52'$

$a - c = 0{\cdot}51616.$

Combining then O and AB, we shall have

$$T = 0{\cdot}7500,$$

which will be + or positive, as ψ is greater than 180°.

$$\text{Then } \frac{\psi}{4} + \frac{\zeta}{2} = 49° \ 19',$$

which gives 40° 21′ for the direction of the new plane in which the forces O and A produce the combined tint of 0·7500. But the angle ω or OEG = 40° 41′, so that the resultant lies in the plane CEG; and hence, if we combine with this resultant, or + 0·7500, the force — 0·7500, produced by CD, the result will be *nothing*. This method is also applicable to the combination of axes of double refraction, the numbers corresponding to *a*, *b*, *c* being in that case the difference between the squares of the velocities of the ordinary and extraordinary rays, as produced by each axis separately at the point E.

The following table of the intensities of the polarising force in biaxal crystals has been given by Sir John Herschel:

	Value of the Highest Tint.	Thicknesses that produce the same Tint.
Nitre	7400	0·000135
Anhydrite, angle of axis 43° 48′	1900	0·000526
Mica, angle of axes 45°	1307	0·000765
Sulphate of barytes	521	0·001920
Heulandite (white), angle of axes 54° 17	249	0·0004021

The numbers belong to the *yellow* ray.

Sect. X.—*On Conical Refraction in Biaxal Crystals.*

Conical refraction.

The phenomenon of conical refraction seen along the axes of biaxal crystals was deduced by Sir W. Hamilton from the undulatory theory, and was discovered experimentally and examined by Professor Lloyd in *arragonite*. It followed from the theory, that a single ray, proceeding from a point within the crystal, and emerging at each of the four poles, must be divided into an *infinite number* of emergent rays, constituting a conical surface; and that a single ray incident externally would be similarly divided.

In order to examine the emergent cone formed in air, Professor Lloyd placed a lens of short focus at its focal distance from the first surface of a plate of *arragonite* 0·49 of an inch thick, having its parallel faces perpendicular to the principal axis of the crystal, and so that the central part of the pencil might have an incidence nearly parallel to the optical axis. He then looked through the crystal at the light of a lamp placed at a considerable distance, and observed a point more luminous than the space around it, having a sort of stellar radiation. In order to examine this phenomenon, he placed a plate of thin metal, having a minute aperture, on the surface of the crystal next the eye, and adjusted the aperture so that the line connected with the luminous point on the first surface might be in the direction of the optical axis. When the adjustment was complete, there appeared at first a luminous circle with a small dark space in the centre, and in this dark central space were two bright points, separated by a narrow and well-defined dark line, as shown in Plate CCCLXXXIV. figs. 39 and 40. When the aperture in the plate was slightly shifted, the phenomena rapidly changed, assuming successively the forms shown in figs. 41, 42, 43. In the first stage of the change the central dark space became greatly enlarged, and a double sector appeared in the centre. The circle was reduced to about a quadrant, and was separated by a dark interval from the sector just mentioned. This is shown in fig. 41. The remote sector then disappeared, and the circular arch diminished, as in fig. 42; and as the inclination of the internal ray to the optical axis was farther increased, these two luminous portions merged gradually into two doubly-refracted pencils. This change is shown in fig. 43. In these experiments the emergent rays were received directly by the eye placed close to the aperture on the second surface.

Polarisation.

Professor Lloyd succeeded in showing the phenomena on a screen with the sun's light, and he found the light sufficiently distinct when the diameter of the section was one and a half inch. Upon examining the cone with a tourmaline, Professor Lloyd was surprised to observe that one radius only of the circular section vanished in a given position of the tourmaline, and that the ray which disappeared ranged through 360°, as the tourmaline was turned through 180°, the rays of the cone being all polarised in different planes. Upon a more attentive examination he discovered the remarkable law, "*that the angle between the planes of polarisation of any two rays of the cone is half the angle between the planes containing the rays themselves and the axis.*" The angle of the cone was found to be 6° 24′, 5° 56′, and 6° 22′; the mean of which is 6° 14.

When the aperture was considerable, such as that formed by a large-sized pin, two concentric circles were seen to surround the axis, the inner one being nearly twice as bright as the outer one, and consisting of unpolarised light, while the outer one was polarised according to the preceding law. By using smaller apertures the inner circle grew less, until it became a point in the centre of the fainter exterior circle, which remained fixed. With a still less aperture a dark space sprung up in the centre, increasing as the aperture diminished, until, with a very minute aperture, the breadth of this central space increased to about three fourths of the entire diameter. In these cases the appearances are as shown in figs. 44 and 45. When the line joining the luminous point on the first surface was slightly inclined to the axis, the appearance was that shown in fig. 46.

Professor Lloyd observed an interesting variation in the phenomena, by substituting a *narrow linear aperture* for the circular one on the first surface of the crystal, this aperture and the one in the plate next the eye being in the plane passing through the optic axes. The line had the appearance shown in fig. 47, swelling out into the form of an oval curve round the optical axis. By using a very minute aperture next the eye, the phenomenon was as shown in fig. 48. When the plate next the eye was slightly shifted, so that the plane passing through the aperture did not coincide with the plane of the optic axes, the curves rapidly changed, preserving, however, the form of the conchoid, whose pole was the projection of the axis of the emergent cone, and asymptote the line on the first surface. These effects are represented in figs. 49 and 50.

The second kind of conical refraction deduced theoretically by Sir W. Hamilton takes place when a single external ray is incident upon a biaxal crystal, so that one refracted ray coincides with an optic axis. In this case there should be a cone of rays within the crystal, the angle of the cone in arragonite being 1° 55′. As this cone will have its rays refracted at emergence, in a direction parallel to the incident ray, they will form a small cylinder of rays in air, the character of whose section by the surface of emergence being only 1° 55′ at a distance equal to the thickness of the crystal.

In order to detect the existence and measure the size of this cylinder, Professor Lloyd used the light of a lamp placed at some distance, and he made its light pass through two small apertures placed in a straight line, the

Polarisation.

one in a screen near the flame, and the other in a plate of metal close to the first circle of the crystal. Under ordinary circumstances, the incident ray will be doubly refracted within the crystal, and the two pencils will emerge parallel to the second surface. Professor Lloyd was able to distinguish these two pencils by means of a lens; and turning the crystal slowly, so as to vary the incidence, he observed a position in which the two rays changed their relative places rapidly on any slight change of incidence, and appeared at times to revolve round one another as the incidence was changed. Being convinced that the ray was now at the critical incidence, Professor Lloyd changed the position of the crystal relative to the incident ray very slowly; and after much care in the adjustment, he at last saw the two rays spread into a continuous circle, and exhibit the phenomena which we have already described in his own words in our history of Optics.

Professor Lloyd measured the angle of the cone by an indirect method, and found it 1° 50′, differing only 5′ from the angle deduced from theory.[1]

Sect. XI.—*On the Effect of Pressure and Heat on the Double Refraction of Crystals with One, Two, and Three Axes.*

Influence of pressure

The influence of pressure and heat in modifying the doubly-refracting structure of bodies that previously possessed that property, and of creating a new doubly-refractive structure in uncrystallized bodies, was first studied by Sir David Brewster.[2]

By applying compressing and dilating forces to minerals, he succeeded in altering their doubly-refracting structure in every direction; but the effect was always most easily seen when it was produced along the real axes of uniaxal crystals, or the resultant axes of biaxal ones, where the effect of the natural forces was either nothing, or compensated. The following were some of the results to which he was led by applying the forces to parallel surfaces.

Axis of Compression and Dilatation parallel to the Axis of the Crystal.

Positive crystals....	Compressed...	Tints rise in Newton's scale.
	Dilated.....	Tints descend in Newton's scale.
Negative crystals...	Compressed...	Tints descend in Newton's scale.
	Dilated.....	Tints rise in Newton's scale.

Axis of Compression and Dilatation perpendicular to the Axis of the Crystal.

Positive crystals....	Compressed...	Tints descend in Newton's scale.
	Dilated.....	Tints rise in Newton's scale.
Negative crystals...	Compressed...	Tints rise in Newton's scale.
	Dilated.....	Tints descend in Newton's scale.

The axis of compression and dilatation is the line perpendicular to the two surfaces pressed together or drawn asunder.

Polarisation.

The above results were obtained by experiments both on uniaxal and biaxal crystals.

When the axis of compression was perpendicular to the axis of double refraction of an *uniaxal* crystal, it was partially converted into a biaxal one with two axes, *the poles of the two resultant axes being distinctly visible.*[3]

Influence of heat.

M. Fresnel was, we believe, the first person who observed the influence of heat in altering the *tints of sulphate of lime* perpendicular to the laminæ, but we are not able to refer to the details of his experiments. Professor Mitscherlich, however, has investigated the action of heat upon this mineral so completely as to include all previous experiments in his results. Having found that heat acts upon calcareous spar differently in different directions, expanding it in the direction of its axis, and slightly contracting it in directions perpendicular to the axis, he sought to determine if any variation in the double refraction was produced by heat. By the method of interferences, and observing the compensation produced by crossing plates of crystals at different temperatures, he observed that a change in the double refraction was produced.

Mitscherlich.

In extending these experiments, Professor Mitscherlich found that the two resultant axes of sulphate of lime inclined 60° to each other at common temperatures, approached each other when heated, till they met, and constituted one axis of double refraction. By increasing the heat they again separated *in a plane perpendicular to the laminæ*. In this experiment the principal axis of double refraction which bisected the optic axes gradually increased, while the second real axis perpendicular to the laminæ diminished and disappeared when the crystal assumed the uniaxal state. A new axis then sprung up in the plane of the laminæ perpendicular to the principal axis.

Sir John Herschel.

Sir John Herschel, in mentioning this remarkable experiment, states that he observed the tints of a plate of sulphate of lime *rise* rapidly in the scale when the plate was moderately warmed by the heat of a candle held at some distance below it, and sink again when the heat was withdrawn. He found, on the contrary, "that mica similarly heated undergoes no apparent change in the position of its axes, or in the size of its rings, though heated nearly to ignition."[4]

Recent experiments.

The extraordinary experiment of Professor Mitscherlich was repeated by Sir David Brewster with one of the specimens of sulphate of lime, in which he discovered one of the resultant axes of this mineral. The following is the account which he has given of this experiment, and of the discovery of a still more curious property in *glauberite*.[5]

"The specimen of sulphate of lime was about one and a half inch thick in the plane of the laminæ, and the system of rings which surrounded this axis was exceedingly minute, with the usual black brush at each end of them. The other system of rings could not be seen in this specimen, owing to the manner in which it was cut. Having brought the crystal to a considerable heat, and exposed it to polarised light, it was a singular sight to see the system of rings travelling along towards the line which bisects the optic axes, like a celestial body passing through the field of a telescope, and changing their form and size as they advanced. The specimen did not permit me to see the two systems unite, and still less to see them open out

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[1] See Irish Transactions, 1833, vol. xvii.; and London and Edinburgh Philosophical Magazine, 1833, No. 8, p. 112, No. 9, p. 207.

[2] Phil. Trans. 1815, p. 1, 60, 1816, p. 167; and Edinburgh Transactions, vol. viii. p. 281.

[3] Edinburgh Transactions, vol. viii. p. 285.

[4] Treatise on Light, sect. 1113.

[5] Lond. and Edin. Phil. Mag. December 1832, vol. i. p. 417.

Polarisation.

again in a plane at right angles to the laminæ; but from the degree of heat which I used, and which drove off the water of crystallization from part of the specimen, I presume that the complete phenomenon cannot be developed without destroying the constitution of the crystal; that is, that after the two systems of rings have opened out in a new plane, they will not return, by cooling, through their state of union, into their primitive inclination of 60° in the plane of the laminæ.

"A property of a similar kind, but perhaps a still more extraordinary one, I discovered some years ago, subsequent to Professor Mitscherlich's discovery; and I have slightly noticed it in a paper on glauberite, published in the Edinburgh Transactions.[1] This interesting mineral has at ordinary temperatures the curious property of *two axes of double* refraction for *red* light, and only *one axis* for *violet* light. If we apply heat to it, the two optic axes for red light gradually close, and, at a temperature which the hand can endure, the two systems of rings for red light have united into one system, so that the crystal has now only one axis of double refraction for red light. By continuing to increase the heat, the two axes separated, and the single system of rings opened out into two systems, lying in a plane at right angles to that in which they were placed at first. The heat was now less than that of boiling water. By increasing it, the inclination of the optic axes gradually increased.

"I now applied artificial cold to a crystal of glauberite at the ordinary temperature of the atmosphere. The inclination of the optic axes for red light increased, as might have been predicted; but, what was very unexpected, a *new axis was created for violet light*, the plane of the two violet axes being coincident with the plane of the two red optic axes at and below the ordinary temperature. An increase of cold increased the inclination of the optic axes for all the colours of the spectrum; the inclination of the axes being *least* for the *most refrangible*, and *greatest* for the least refrangible rays.

"These results appear very complicated when we begin with the effects at an ordinary temperature, and view them in the manner in which they were observed; but if we commence the experiments at a low temperature, such as the freezing point, the order and connection of the phenomena will be more easily understood.

"At 32° glauberite has two axes of double refraction for rays of all colours, the inclination of the axes for the violet rays being least, and that for the red the greatest. As the temperature rises, the optic axes for all colours gradually approach, and the axes for violet first unite into one. At this time the crystal has two axes for all the other colours; but as the heat increases, all the other pairs of axes unite in succession, and form a single system of rings. But before this has taken place, the axes for violet rays have opened up again in a plane at right angles to that in which they originally lay, and they are followed by all the other pairs of axes; so that at a temperature much below that of boiling water, each pair of axes appears with different inclinations arranged in a new direction.

"During all the changes which have been described above, the crystal has preserved its constitution; and by abstracting the heat, the phenomena are all repeated in an inverse order.

"If the crystal should happen to be observed at that temperature, which very often occurs when the greenish-yellow or most luminous rays have the optic axes corresponding to them united, or form a single system of rings, then the blue rays will have two systems of rings lying in one plane, and the red rays also two systems of rings in a plane at right angles to this. In two rectangular positions, namely, when the planes of the double axes coincide with or are at right angles to the plane of primitive polarisation, the black cross will be very distinct; but in intermediate positions it will be much less so, and the uniaxal system of rings which predominates, from the greater intensity of their light, will have that indistinctness of character which, whenever it occurs, indicates a peculiar action of the doubly-refracting force on the differently-coloured rays. When the black cross is perfect and equally distinct in all positions, while the colours of the rings deviate from those of Newton's scale, then the axes for all colours are obviously coincident, and the peculiarity in the colour of the rings is owing to an irrationality in the action of the doubly-refracting forces on the differently-coloured rays."

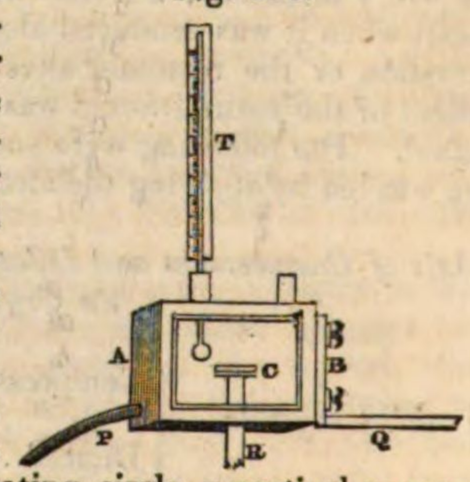
Polarisation.

A series of highly valuable experiments on the changes which temperature produces in the double refraction of crystals,[2] have been made by Professor Rudberg of Upsal. Professor Mitscherlich having only determined the ratio between the mean double refraction of Iceland spar in a cold and in a heated state, without ascertaining the separate variations in each pencil, Professor Rudberg was desirous of supplying this desideratum.

Professor Rudberg.

For this purpose he constructed a box, AB, having four of its faces double, so as to enclose a space which received through the pipe P, and retained, the steam from a boiler. This space communicated also with the external air. The other two faces of the box were formed with plates of mica. The inner box, therefore, contained only air, which was heated by the surrounding steam. A thermometer T indicated the temperature of the air. A tube R, passing through the two lower surfaces of the box, formed a free communication between the interior and the exterior air, so that their elasticity was the same. Through this tube R, without touching its sides, there rose from the centre of the repeating circle a vertical copper rod, carrying a plate C, upon which the crystal was placed. This rod was attached below to another plate of copper, which rested on a ring of copper, which, having teeth upon its circumference, could be moved by a screw. By this arrangement he could perform the experiments as readily as if there had been no heating apparatus to obstruct them. The heating apparatus was attached by a rod Q of iron rising from the masonry on which the repeating circle rested.

Fig. 152.



The experiments were made to determine the index of refraction of the ray F of Fraunhofer's spectrum near the boundary of the *green* and *blue* spaces. In this way he obtained the following results.

1. Calcareous Spar. Refracting angle of prism 59° 55′ 9″.

Calcareous spar.

a. Ordinary Ray. The minimum deviation of the line F produced by the prism was 52° 53′ 43″. With a difference of temperature of 64° (Reaumur, we presume), this ray suffered no change in its deviation; from which our

[1] Edin. Trans. vol. xi. part ii. page 273.

[2] This interesting paper was communicated by the author to Sir David Brewster, and published in the London and Edinburgh Philosophical Magazine, December 1832, vol. i. p. 409.

Polarisation.

author concluded, *that the refractive power of* CALCAREOUS SPAR *for the ordinary ray either does not change at all with the temperature*, or decreases with it by a quantity *extremely small*. The index of refraction of F at the ordinary temperature was 1·66802.

b. Extraordinary Ray. By the difference of temperature of 64°, the deviation was increased 2′ 26″, or 2′ 34″ when corrected, which gives for the index of refraction,

1·49118 at 64°
1·49075 at ordinary temperature

0·00043 increase.

Hence, *in the extraordinary ray, a rise of temperature of* 64° increases the index of refraction 0·00343.

Polarisation.

Professor Rudberg confirmed this result in the presence of Professor Mitscherlich in 1832.

Rock crystal.

2. ROCK CRYSTAL. Refracting angle of prism 45° 20′ 5″.

In both the ordinary and extraordinary ray, the deviation was *decreased* by a rise of temperature 42″. The indices for the ray F became in the extraordinary ray 1·55868, being 0·00028 more than at the ordinary temperature; and in the ordinary ray, 1·54944, being 0·00026 less.

Arragonite.

3. ARRAGONITE. With four prisms he obtained the following results.

	Prism, No. 1.	No. 2.	No. 3.	No. 4.
Variation of the deviation	— 5′ 8″	— 1′ 53″	— 4′ 3″	— 2′ 58″
Variation of refracting angle	...	+ 16″	— 1′ 53″	— 48″·6

When corrected for the deviation of the plate of mica, they became

Variation of deviation	— 1′ 47″	— 3′ 57″	— 2′ 52″
Variation of angle	+ 30 0	— 1 44	— 40″

Hence he obtained the following indices of refraction:

	No. 2.	No. 3.	No. 4.
At ordinary temperature	1·53478	1·69510	1·69058
At increased temperature	1·53416	1·69421	1·68976
Changes on index	— 0·00062	— 0·00089	— 0·00082

Hence, says our author, *the double refraction of arragonite appears to decrease a little with the temperature*, because the refracting power in the direction of the axis A has diminished in a smaller ratio than that along the axes B and C. In other respects arragonite comports itself quite differently from calcareous spar. The axis A of arragonite obviously corresponds with the axis of crystallization of the spar; but notwithstanding this, the refractive power in this direction diminishes in the former, and, on the contrary, increases in the latter, besides, that in the direction perpendicular to the axis A, the refractive power diminishes considerably in arragonite, whilst, on the contrary, it undergoes almost no change in calcareous spar.

Regular double refraction produced by pressure.

While heat and pressure thus modify the doubly-refracting structure in minerals, they are capable of creating it with *regular axes* in several soft substances. This effect is quite different, as we shall soon see, from that which is produced upon bodies by pressure, where the result is modified by the external form of the body, and where the double refraction disappears when the heat or pressure is removed, or when the body is subdivided. A permanent change is induced upon the soft solids in question, and, when subdivided, each part of the mass or plate preserves the property communicated to it. Sir David Brewster described, in the Philosophical Transactions for 1815,[1] the original experiment which he made on this subject with a mixture of rosin and white wax; but in the same work for 1830,[2] he has given a detailed account of his experiments, and of the conclusions to which they lead respecting the origin of the doubly-refracting structure. The following is the fundamental experiment described by our author.

"I took a few drops of the melted compound (rosin and bees' wax), and placed them in succession on a plate of thick glass, so as to form a large drop. Before it was cold I laid above the drop a circular piece of glass about two thirds of an inch in diameter, and, by a strong vertical pressure on the centre of the piece of glass, I squeezed out the drop into a thin plate. This plate was now almost perfectly transparent, as if the pressure had brought the particles of the substance into optical contact.

"If we expose this plate to polarised light, we shall find that it possesses one *positive* axis of double refraction, and exhibits the polarised tints as perfectly as many crystals of the mineral kingdom. The structure thus communicated to the soft film by pressure does not belong to it as a whole, nor has it only one axis passing through its centre, like a circular piece of unannealed glass. In every point of it there is an axis of double refraction perpendicular to the plates, and the doubly-refracting force varies with the inclination of the incident ray to this axis, as in all regular uniaxal crystals.

"When the two plates of glass are drawn asunder, we can remove one or more portions of the compressed plate, and these portions act upon light exactly like plates of uniaxal mica or hydrate of magnesia, and develope a doubly-refracting force of nearly equal intensity."

Cause of double refraction.

By reasoning from this experiment, our author is led to the opinion that double refraction is acquired by the particles of bodies at the instant of their aggregation, and arises from the pressures produced in the direction of three rectangular axes, by the forces of aggregation. When these forces are very weak, double refraction will not be produced; when they are sufficiently strong and of equal intensity, they will produce tessular crystals; when they are equal in two rectangular directions, they will produce uniaxal crystals; and when they are unequal in all the three directions, they will form biaxal ones. In this way all the phenomena of cleavage may be readily explained.

Upon some substances heat performs the same part as pressure; but our limits will not permit us to detail our author's experiments on this subject.

SECT. XII.—*On the Deviation of the Polarised Tints from those of Newton's Scale.*

In all his investigations respecting the colours of thin plates, M. Biot happened to use only such crystals as

[1] Page 31, 32.

[2] Page 87.

Polarisation.

gave polarised tints similar to those of Newton's scale, and he therefore considered this to be their character. In 1813, however, when Sir David Brewster described the rings in topaz, he gave a list of all the colours in different azimuths round the optic axes, and he not only found these colours to vary in these different azimuths in the same ring, but observed some colours at the extremity of the optic axes. In his paper on the laws of polarisation, published in the Philosophical Transactions for 1818, he remarks, that "in almost all crystals with two axes, the tints in the neighbourhood of the resultant axes, when the plate has a considerable thickness, lose their resemblance to those in Newton's scale, as will be more minutely described in another paper." In April 1817 he communicated to the Royal Society of Edinburgh an account of the extraordinary system of rings in the apophyllite from the Tyrol, which consisted of *purple* and *yellow* light, like the residual colours arising from the combination of irrational spectra.

In examining the colours of the polarised rings in biaxal crystals, he was led to divide them into two classes, viz. 1. Those that had the *red* ends of the rings *inwards*, or between the resultant axes, and the blue ends *outwards*. 2. Those that had the red ends of the rings *outwards*, and the *blue* ends of the rings *inwards*.

The crystals in which the deviation is very striking are given in the following table.

Class 1.—*Red ends inwards.*

Nitre.	Carbonate of lead.
Sulphate of barytes.	Sulphato-bicarbonate of lead.
——— of strontites.	Hyposulphate of strontia (Herschel).
Tartrate of potash and soda.	Tartrate of potash.
Phosphate of soda.	
Arragonite.	

Class 2.—*Red ends outwards.*

Topaz.	Native borax.
Mica.	Sulphate of magnesia.
Anhydrite.	Arseniate of soda.

Unclassed.

Chromate of lead.	Superoxalate of potash.
Muriate of mercury.	Oxalic acid.
——— of copper.	Sulphate of iron.
Oxynitrate of silver.	Cymophane.
Sugar.	Felspar.
Crystallized Cheltenham salts.	Benzoic acid.
	Chromic acid.
Nitrate of mercury.	Nadelstein.
——— of zinc.	Hyposulphate of soda (Herschel).
——— of lime.	

Sir John Herschel found anomalous tints in hyposulphate of lime, and Vesuvian, both crystals with one axis, a circumstance which we ascribe to that axis being the resultant of three axes, two of which are equal.

In examining the rings formed by biaxal crystals, Sir David Brewster found that the black spot at the point of compensation was not in the centre of the rings, and the position of this spot for *topaz* is given in his table of these colours.[1]

Sir John Herschel's experiments.

It is to Sir John Herschel, however, that we owe the complete investigation of this subject in reference to biaxal crystals. By using homogeneous light, he found that the angle of the resultant axes P*Op*, fig. 129, was different for the different colours of the spectrum, varying, in the case of *tartrate of potash and soda*, from 75° 42′ in *red* light, to 55° 14′ in *violet* light, so that with *white* light we have a system of rings, consisting of five rings of all colours, overlapping each other, and these five constituting an irregular system, unlike those produced by ordinary crystals.

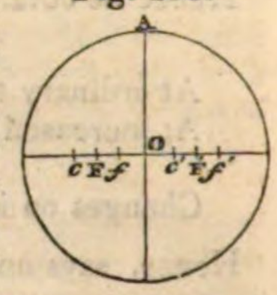
Polarisation.

In crystals where the displacement of the rings is great, the *oval central spots* seen in Plate CCCLXXXIII. figs. 32, 33, and 34, are drawn out, as Sir John Herschel remarked, into long spectra or tails of *red*, *green*, and *violet* light, and the extremities of the rings are distorted and highly coloured, as in fig. 51, Plate CCCLXXXIV. When we view these spectra with coloured media, they are found to consist of well-defined spots of the several simple colours, arranged on each side of the principal section, as shown in fig. 52.

These results are capable of being rigorously calculated by the law of resultant axes given by Sir David Brewster, and may be considered as a proof of that law. If this were not the case, *tartrate of potash and soda* would have two axes for every different ray of the spectrum, and four series of poles extending each over a space of *ten degrees*.

In order to show how these phenomena may be calculated by two axes, let O and A, fig. 153, be two negative axes, which in *red* light compensate each other at F and F; then, if O and A had the same proportional action on the *violet* and other rays as on the *red* rays, F would also be the point of compensation for the *violet* and other rays. In this case F would be the centre of all the systems of rings, as in uniaxal crystals, and the tints those of Newton's scale. But if the axis O has a greater proportional action upon the violet and other rays than A, the point of compensation will be at *f*, which will be the centre of the violet system of rings, the centres of all the other systems being between F and *f* if the action of O upon them is of an intermediate nature. This is the case with all the crystals in Class 1 of the foregoing table. On the other hand, if O has a less proportional action on the violet than on the red, *c*, *c* will be the points of compensation for the *violet* rays, and the centres of the two systems of violet rings.

Fig. 153.



The most remarkable instances of deviated tints are those in *apophyllite*, a crystal with one axis, discovered by Sir David Brewster. Sir John Herschel, in examining a number of apophyllites, found that some specimens exercise *negative* action upon the rays at one end of the spectrum, a positive action upon rays at the other end, and no action at all upon the mean refrangible rays, the doubly refracting action ceasing, in the one case, in the yellow rays, and in another in the indigo.[2] In other specimens, the diameter of the rings was nearly the same for all the colours of the spectrum, and hence the rings were approaching to a series of black and white ones. All these phenomena may be separately calculated by the law of resultant axes already mentioned, on the supposition that apophyllite has three rectangular axes of double refraction. Sir David Brewster had discovered, in the tesselated apophyllite, portions which had *two* axes co-existing with portions that had *one* axis; and in his coloured drawings of the phenomena exhibited by this mineral, he has pointed out a most extraordinary law of symmetry which regulates its varying double refraction; and as he had shown that a double dispersive power existed in the same crystal, the following explanation of the remarkable phenomena of apophyllite approaches to the character of demonstration.

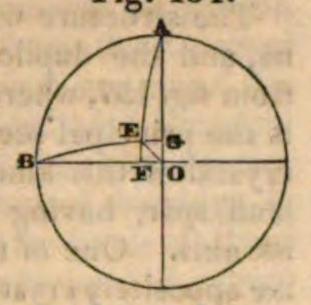
Let O be the positive axis of uniaxal apophyllite, and let A and B be two *positive* axes which, if equal, would produce a *negative* axis at O. But as the real axis at O is a positive one, the apparent or finally resultant axis at

[1] Phil. Trans. 1814, p. 204, 205.

[2] Cambridge Trans. vol. i. p. 21–24.

Polarisation. O will be a single axis, *negative* if the *negative* is the strongest, and positive if the positive is the strongest. Let us now suppose that the two axes at O have equal intensity, viz. + O = — O for *yellow* light (— O being the resultant of + A and + B), and that — O acts more powerfully upon the *red* rays than + O, while + O acts more powerfully upon the *violet* rays. In this case the two axes + O, — O will exactly compensate each other. In *yellow* light, a yellow ray will experience neither double refraction nor polarisation; whereas in *red* light, the predominance of — O will leave a single negative axis for *red* rays, and produce a *negative* system of rings; and in *violet* light the predominance of + O will leave a single *positive* axis of double refraction for violet rays, and consequently a *positive* system of rings. This compensation resembles that of a compound lens, consisting of a *convex* and *concave* lens of equal curvature, of such a glass that their refractive index for *yellow* light is equal, while the index of refraction for the *violet* rays is *greater* in the *convex* lens, and the index for the *red* rays *greater* in the *concave* lens. Such a lens will *converge* the *violet* rays, *diverge* the *red rays*, and *produce no deviation* at all in the *yellow* ones; that is, the same compound lens will be a *plane* lens in *yellow* light, a *convex* one in *blue* light, and a *concave* one in *red* light. Hence each order of colours in apophyllite is as it were a secondary or residual spectrum arising from the opposite action of unequal negative and positive axes. From the fact of some apophyllites exercising a negative action, Sir David Brewster stated his expectation that apophyllites might be found in which the double refraction is negative for all the rays of the spectrum; and several years afterwards he discovered the remarkable mineral of *oxahverite*, which is an apophyllite with this property.[1]

Fig. 154.



The phenomena of glauberite already described afford an additional illustration of these views.

Sect. XIII.—*On Crystals with Planes of Double Refraction exemplified in Analcime.*

Analcime. *Analcime* or *Cubizite*, a mineral which has been ranked among the cubical crystals, might have been expected to have had no double refraction if this had been its form. It was found, however, by Sir David Brewster, to be a singular body in its action upon light, and to exhibit the extraordinary property of many planes of double refraction, or planes to which the doubly-refracting structure was related in the same manner as it is to *one* or *two* axes in other minerals.

Analcime crystallizes most commonly in the form of the *icositetrahedron*, as in fig. 53, Plate CCCLXXXIV. If we suppose a complete crystal of it to be exposed to polarised light, it will give the remarkable figure shown in fig. 53, where the dark shaded lines are planes in which there is neither double refraction nor polarisation, the double refraction and the tints commencing at these planes, and reaching their maximum in the centre of the space enclosed by three of the dark lines. The tints are those of Newton's scale, and are negative in relation to each of the four axes of the *icositetrahedron*. When light is transmitted through any pair of the four planes which are adjacent to any of the three axes of the solid, it is doubly refracted, the least refracted image being the extraordinary one, and consequently the double refraction negative in relation to the axes to which the doubly-refracted ray is perpendicular.

Polarisation. If we suppose the crystal to have the form of a *cube*, the planes of double refraction will be, as in fig. 54, a plane passing through the two diagonals of each face of the cube.

The tints vary as the square of the distance from the nearest plane of double refraction.

The tints shown in figs. 53 and 54 cannot of course be seen at the same time, but are deduced from observations made by transmitting polarised light in every direction through the crystal.

Sect. XIV.—*On the Double Refraction and Polarisation of Composite Crystals.*

Composite crystals. In all the crystallized bodies whose action upon light we have been considering, excepting *analcime*, the phenomena are identical in all parallel directions, the smallest fragment having the same property as the largest, from whatever part of the crystal it is taken.

In the mineral world, however, and among the products of artificial crystallization, there occur crystals which are composed of several individual crystals whose axes are not parallel. These crystals sometimes occur in such regular symmetrical forms, that mineralogists have long regarded them as simple forms; and it is probable that they would have still been viewed in this light, if they had not been exposed to the scrutiny of polarised light.

One of the most remarkable of these composite crystals is Iceland spar, some specimens of which were observed, even by Bartholinus and Huygens, to exhibit phenomena quite different from those which we have already described. The property which they possessed of multiplying the images of a luminous body seen through them had been carefully studied by Benjamin Martin, Professor Robison, Lord Brougham, Malus, and others; but until the publication of Malus' work on Double Refraction, no sound explanation was given of these remarkable phenomena.

Malus describes the phenomena as produced by fissures parallel to the surface of the variety of this mineral described by Haüy under the name of *chaux carbonatée equiaxe*. He explains the duplication of the images on the supposition that there is a *fissure* or real opening between the conjoined faces of the spar, and he ascribes the varying tints to a cause not adequate to the production of such splendid phenomena,—to the colouring of the thin plate of air included in the fissure. He states correctly, that the secondary images are doubled by *two* fissures, tripled by three, &c.[2]

This class of phenomena was particularly investigated by Sir David Brewster, who found that the fissures described by Malus *were thin crystallized laminæ of Iceland spar*, having their axes of double refraction inclined to that of the portions of the crystal which it separated; that these laminæ varied in thickness, the thinnest producing a large system of rings, and the thicker plates smaller systems, the plates being sometimes so thick that no colours whatever appeared. Hence it was obvious *that each crystal of this kind was a polarising and an analysing apparatus, the thin laminæ being the plate which exhibited its polarised tints in this singular position.*

In order to understand this remarkable structure, we have represented the laminæ in fig. 155 by the planes ABCD, *ebcg*, *afhd* parallel to the edges EGFH, and also to the long diagonals of the rhomboidal faces, or perpendicular to the short diagonal EF. When we look through a crystal with only *one* of these laminæ, we observe the two principal images of the candle A, B, or luminous

[1] Edinb. Journal of Science, No. xiii. p. 115.

[2] *Théorie de la Double Refraction*, p. 194–198.

Polarisation.

body, while at a vertical incidence, and separated just as they would have appeared in a common crystal of the same thickness. But on each side of this double image is a single-polarised image C and D, C being polarised in the same plane as B, and D in the same plane as A. Let us suppose that these phenomena are seen through a rhomb with only one plane ABCD (fig. 155), and through the faces EACD, BEHC. Then, if we incline the rhomb in different directions slightly, we shall see the images C, D disappear when they have a certain distance from A, B. If we incline the rhomb, bringing EA nearer the eye than CD, the images C, D will approach to AB, and will be found to disappear nearer and nearer to AB as the inclination is increased, it being necessary to bring the edge EG nearer the eye than AD, to make C and D disappear. While C and D are thus approaching to A, B, they become less and less coloured till they are all white. If we incline the rhomb in an opposite direction, so that GD is brought nearer the eye than EA, the images C, D recede from A, B, and become more highly coloured, the two images A, B becoming also coloured. The images C, D sometimes appear doubled when this inclination is going on, but it is only a duplicity of colour, so to speak, in consequence of the spectrum being divided by portions of it passing into the reflected pencil. When we bring EC nearer the eye than AD, the colours increase, A and B become also coloured, and an apparent colorific duplication of the images C and D takes place. If the rhomb is inclined in an opposite direction, so that AD is brought nearer the eye than EC, the images C, D become also at first more coloured; but by increasing the inclination, the image C recedes rapidly on the right side from A, B, contracts in breadth, and becomes prismatically coloured, the spectrum which it exhibits being subdivided by several black lines or bands, the parts of the spectrum corresponding to these black lines or dark bands having passed into the reflected ray. The spectrum D recedes as rapidly to the left, expanding in breadth, and even disappearing, as well as the images A, B.

Fig. 155.

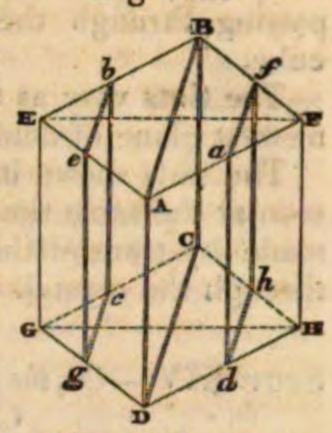
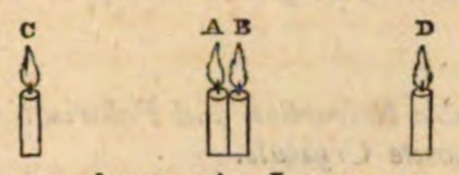


Fig. 156.



All these phenomena are more finely seen, and the law of their changes more easily detected, if, instead of a candle, we look at a long line of light, such as the narrow opening between the edges of the window-shutters.

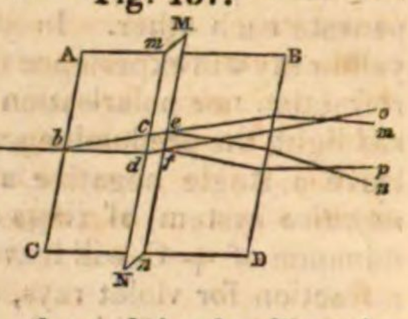
If we look through the faces ADFH, ADEG of the rhomb, placing a prism of glass with an angle of 12° or 15° upon one of the faces, to permit the refracted rays to emerge at a moderate angle of deviation, the prismatic images formerly described will be large spectra, subdivided by black spaces into 4, 5, 6, &c. coloured images of the candle, or of the long luminous line, exhibiting one of the most magnificent phenomena that can be witnessed.

These phenomena vary, of course, with the thickness of the enclosed laminæ, and as the laminæ increase in thickness the subdivisions of the spectral images become more numerous.

When we reflect light from these laminæ, ABCD, for example, by allowing the light to enter by the face BFHC, and emerge through the face AFHD, the boundary of total reflection is marked by a series of brilliant rectilineal fringes, polarised in the same manner as the image C, which is now the lowermost. When the light is transmitted through the laminæ at the boundary of total reflection, by entering through the face BECG, and emerging through AFHD, a series of rectilineal fringes complementary to the former reflected series is seen. They also are polarised in the same plane as C, or the lowermost secondary image, and become much more distinct, by causing the oppositely polarised pencil to disappear. Polarisation.

The structure which produces the preceding phenomena, and the duplication of the images, will be understood from fig. 157, where ABCD is the principal section of a crystal of this kind of Iceland spar, having AD for its axis. One of the laminæ oppositely crystallized is shown at M*m*, N*n*, but much thicker than they are generally, the angles A*m*M, D*n*N being 141° 44′. A ray of ordinary light R*b* will be refracted in the lines *bc*, *bd*. These rays entering the laminæ MN, will be again refracted doubly; but as the vein is so thin as to produce the system of uniaxal rings, the colours will vary with the thickness of the film and the inclination of the ray to the axis of the lamina. The four pencils will emerge from the lamina at *e*, *f*, and will be refracted again, as in the figure, into the pencils *em*, *en*, *fo*, *fp*, the colours of *en*, *fo* being complementary to those of *em*, *fp*.

Fig. 157.



That the multiplication and colour of the images are produced by the causes above explained, has been proved by Sir David Brewster, by actually placing laminæ of different crystals between the prisms AN, BN. In this way, by introducing different films in different azimuths, most beautiful combinations may be produced.

Modifications of the rings in Iceland spar.

If we grind down the angles A and B, so as to have two faces perpendicular to the axis AB, the uniaxal system of rings is beautifully modified by the action of the lamina MN; and that this was the cause of the singular transformations which the rings experienced in different crystals, was proved by the author above quoted, by inserting laminæ between two plates of the *chaux carbonatée basée* of Haüy, whose natural faces are perpendicular to the axis. These transformations are exceedingly beautiful. Some of them are shown in figs. 55, 56, and 57, one of the rings consisting of eight dark radii, while the complementary system has its inner circle marked with *eight* dark-coloured spots. These rings suffer beautiful changes, both by the motion of the plane round its axes when the analysing plate is stationary, and by the motion of the analysing plate when the rhomb is stationary. In studying these phenomena in a great variety of crystals intersected with one or more laminæ, Sir David Brewster noticed a very remarkable fact. A rhomb of spar which produced in one part of it the transformed systems already mentioned, exhibited a singular effect in another part, where *the crystallization appeared perfect and simple*, and where there were decidedly no veins or laminæ. In one position or azimuth of this crystal, this portion gave, as might have been expected, the regular system of rings with the black cross shown in fig. 29. But upon turning it round 45°, all the rings became *elliptical*, as shown at ABCD in fig. 58, the *first* order of colours in one quadrant having joined the *second* order of colours in the adjacent quadrant. The arms of the black cross took the contorted position *abc*, *def*, the continuations of it afterwards, viz. *am*, *cn*, *do*, *fp* being so very faint as to show the continuity of the elliptical rings. In this figure the rings of the same order are marked with the same figure. The very same phenomenon, which points to important theoretical consequences, was observed by the same author in another rhomb of spar *wholly without veins*, but the rings were not so elliptical as in fig. 58.

This composite structure was discovered by Sir David

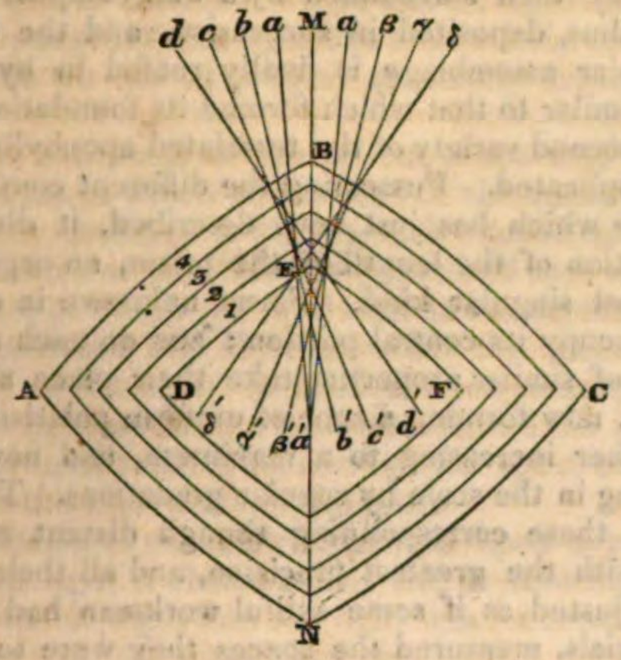
Polarisation.

Brewster in various minerals, and he has described it very minutely in the case of *Brazilian topaz*, *sulphate of potash*, and *apophyllite*.

Brazilian topaz.

Sir John Herschel, we believe, first noticed this structure in Brazilian topaz, and observed that the central portion of the crystal had a different colour from the external portion, and that the plane of the principal section of the different parts made angles of 20 ±°. Sir David Brewster found very remarkable arrangements of the coloured portions, which he has represented in coloured drawings in the Cambridge Transactions, vol. ii. In some of these crystals the structure was tesselated, as in fig. 158, where ABED, CBEF, are the two external tesselæ, at one of the obtuse angles of the rhomboidal section. If we suppose

Fig. 158.



that these tesselæ are divided into *four* laminæ, 1, 2, 3, 4, and that MN is the principal section, or one of the neutral axes of the central portion of the crystal contiguous to DEF, then the laminæ 1, 1 have their principal section in the direction *aa'*, forming a very small angle with MN; the laminæ 2, 2 have their principal section in the line *bb*, and so on to the superficial laminæ 4, 4, which have their principal section in the direction *dd'*, inclined from 10° ± to 22° ± to MN, the inclination varying in different crystals. The lines *aa'*, *bb'*, &c. are also the principal sections of the corresponding laminæ on the side NC. In like manner, the principal sections *αα'*, *ββ'*, &c. of the laminæ in BCFE, are the principal sections of the corresponding laminæ on the other side AN. As the laminæ, however, are infinite in number, the principal sections have every possible direction between *dd'* and *δδ'*.

Sulphate of potash.

The *bipyramidal sulphate of potash*, which Count Bournon supposed to be a simple crystal, was found by Sir David Brewster to be a tesselated crystal, composed of three pair of crystals of the prismatic sulphate of potash combined so that each pair had their principal axis parallel. When exposed to polarised light, each pair gave the system of biaxal rings, and when held at a distance from the eye, had the tesselated appearance shown in fig. 59, Plate CCCLXXXIV., each opposite pair of the triangles having the same tint.[1]

Apophyllite.

The most remarkable of this class of minerals, and indeed the most remarkable body in the whole mineral kingdom, is the *tesselated apophyllite*. It crystallizes most commonly in four-sided rectangular prisms, like CD, fig. 60. If we remove the uppermost slice A and the undermost B to the thickness of between the 50th and the 100th of an inch, and examine it either by the microscope or by polarised light, we shall find that it is like other uniaxal plates, giving a single system of rays having the very peculiar colours which have been already described. A number of veins appear at the edges, as shown in the figure. All the other slices lying below this exhibit the beautiful tesselated figure shown in fig. 61. The outer case MNOP, which, as it were, binds together the internal portions, consists of a great number of parallel veins or plates, which give the colours of grooved surfaces. This frame encloses *nine* different crystals, namely, the central lozenge *abcd*, the *four* prisms A, B, C, D with trapezoidal bases, and the *four* triangular prisms *ehl*, *lmn*, *nkg*, *gfe*, all of which are separated by distinct lines or veins, which are nearly all visible by the microscope by a proper method of illumination. In polarised light they are all seen with great facility.

Polarisation.

The most extraordinary fact connected with this structure is, *that the central lozenge has only* ONE *axis of double refraction, like the terminal plates A, B, fig.* 60, *while the four prisms A, B, C, D, and the four triangular spaces, have* TWO *axes.* In A and D the planes of the resultant axes are coincident, as in the opposite triangles of sulphate of potash, and lie in the direction MN, while the planes of the resultant axes in B and C lie in the direction OP.

When the plate MONP is exposed to polarised light and turned round its axis before the analysing plate, the lozenge *abcd* will be dark in every position of the plate, while the portions A, B, C, D will depolarise the light, or be luminous, when MO or ON are parallel or perpendicular to the plane of primitive polarisation.

Remarkable as is the structure which we have now described, it is greatly excelled in beauty by another variety of Faroe apophyllite, in which Sir David Brewster discovered the most extraordinary organization. He has given an enlarged coloured drawing of the fine symmetrical tints which it exhibits in polarised light, in the Edinburgh Transactions; but we hope its structure may be understood by the following description which he has given of it. The crystals have a greenish-white tinge, and are aggregated together in masses. The quadrangular prisms are in general below one twelfth of an inch in width; they are always unpolished on their terminal planes; they have the angles at the summit more deeply truncated than the other quadrangular prisms from Faroe; they are always perfectly transparent; and may sometimes be detached in a complete state, with both their terminal summits.

"In examining this variety of apophyllite, I was enabled, by the perfection of the crystals, to study their structure through the natural planes, and at right angles to their axes. The phenomena which this investigation presented to me were of a very singular and unexpected nature. In symmetry of form and splendour of colouring they far surpassed any of the optical arrangements that I had seen, while they developed a singular complexity of structure, and indicated the existence of new laws of mineral organization.

"When a complete crystal of this variety of apophyllite is exposed to polarised light, with its axes inclined 45° to the plane of primitive polarisation, and is subsequently examined with an analysing prism, it exhibits, through both its pair of parallel planes, the appearance shown in fig. 62. In turning the crystal round the polarised ray, all the tints vanish, re-appear, and reach their maximum at the same time, so that they are not the result of any hemitropism, but arise wholly from a symmetrical combination of elementary crystals possessing different primitive forms and different refractive and polarising powers. The difference in the polarising powers is well shown by the variation of tint; and the difference of refractive power may be observed with equal distinctness by examining the

[1] See Edinburgh Philosophical Journal, vol. i. p. 1.

Polarisation.

crystal with the microscope under favourable circumstances of illumination, when the outlines of the symmetrical forms shown in fig. 62 will be clearly visible.

"In examining the splendid arrangement of tints exhibited in the figure, the perfect symmetry which appears in all its parts is particularly remarkable. The existence of the curvilineal solid in the centre; the gradual diminution in the length of the circumscribing plates, in consequence of which they taper, as it were, from the angles of the central rectangle to the truncated angles at the summits; but, above all, the reproduction of similar tints on each side of the central figure, and at equal distances from it, cannot fail to strike the observer with surprise and admiration.

"The tints exhibited by each crystal vary, of course, according to its thickness; but the range of tint in the same plate, and at the same thickness, generally amounts in the largest crystals to three of the orders of colours in Newton's scale. The central portion, and the two squares above and below it, have in general the same intensity, while the four segments round the central portion, and some of the parts beyond each of the squares, are also isochromatic. In the central part the colours have a decided termination; but towards the summit of the prism their outline is less regular, and less distinctly marked; though this irregularity has also its counterpart at the other termination. A part of these irregularities is sometimes owing to the longitudinal striæ on the natural faces of the crystal, so that by carefully grinding these off, the beauty and regularity of the figure is greatly improved.

"In order to ascertain the order of the colours polarised by the crystal, and observe in what manner they passed into one another, I transmitted the polarised light in a direction parallel to one of the diagonals of the quadrangular prism, and thus obtained, as it were, a section of the different orders of colours from the zero of their scale. The result of this experiment, which is shown in fig. 63, was highly interesting, as it displayed to the eye not only the law according to which the intensity of the polarising forces varied in different parts of the crystal, but also the variation in the nature of the tints, and the connection between these two classes of phenomena. At the points in the diagonal *mn*, opposite to *ba* of the crystal, the tints rose to the *seventh* order of colours; and in other two places opposite to *cd*, they were only to the *sixth*; while near the summits at *mn*, they descended so low as the *fourth* order. Hence it follows that the four curvilineal segments, fig. 62, are next to these in intensity; that the central portions of the squares are again inferior to these; and that the weakest polarising force is near the summit of the prisms. At *ab*, the *fourth*, *fifth*, and *sixth* fringes have a singularly serrated outline, exhibiting, in a very interesting manner, the sudden variations which take place in the polarising forces of the successive laminæ.

"Having thus described the structure and properties of the tesselated apophyllite, it becomes interesting to inquire how far such a combination of structures is compatible with the admitted laws of crystallography. The growth of a crystal, in virtue of the aggregation of minute particles endowed with polarity, and possessing certain primitive forms, is easily comprehended, whether we suppose the particles to exist in a state of igneous fluidity or aqueous solution. But it is a necessary consequence of this process, that the same law presides at the formation of every part of it, and that the crystal is homogeneous throughout, possessing the same mechanical and physical properties in all parallel directions.

"The tesselated apophyllite, however, could not have been formed by this process. It resembles more a work of art, in which the artist has varied, not only the materials, but the laws of their combination.

"A foundation appears to be first laid by means of an uniform homogeneous plate, the primitive form of which is pyramidal. A central pillar, whose section is a rectangular lozenge, then rises perpendicularly from the base, and consists of similar particles. Round this pillar are placed new materials, in the form of four trapezoidal solids, the primitive form of whose particles is prismatic; and in these solids the lines of similar properties are at right angles to each other. The crystal is then made quadrangular by the application of four triangular prisms of unusual acuteness. The *nine solids* arranged in this symmetrical manner, and joined by transparent veins performing the functions of cement, are then surrounded by a wall composed of numerous films, deposited in succession, and the whole of this singular assemblage is finally roofed in by a plate exactly similar to that which formed its foundation.

"The second variety of the tesselated apophyllite is still more complicated. Possessing the different combinations of the one which has just been described, it displays, in the direction of the length of the prism, an organization of the most singular kind. Forms unknown in crystallography occupy its central portion; and on each side of it particles of similar properties take their place at similar distances, now forming a zone of uniform polarising force, now another increasing to a maximum, and now a third descending in the scale by regular gradations. The boundaries of these corresponding though distant zones are marked with the greatest precision, and all their parts as nicely adjusted as if some skilful workman had selected the materials, measured the spaces they were to occupy, and finally combined them into the finest specimen of natural mosaic.

"The irregularities of crystallization which are known by the name of *macle* or *hemitrope* forms, and those compound groups which arise from the mutual penetration of crystals, are merely accidental deviations from particular laws which govern the crystallizations in which they occur. The aberrations themselves testify the predominance of the laws to which they form exceptions, and they are susceptible of explanation by assuming certain polarities in the integrant molecules. The compound structure of the apophyllite, however, cannot be referred to these capricious formations. It is itself the result of a general law, to which there are no exceptions, and when more deeply studied and better understood, it must ultimately lead to the introduction of some new principle of organization, of which crystallographers have at present no conception.

"The difficulty of accounting for the formation of apophyllite is in no way diminished by giving the utmost license to speculation. We cannot even avail ourselves of the extravagant supposition of a crystalline embryo, which, like that of animal and vegetable life, gradually expands to maturity. The germ of plants and animals is nourished by a series of organs, of which, however recondite be the operation, we yet see the action and witness the effects; but in the architecture of apophyllite no subsidiary organs are seen. The crystal appears only in its state of perfection; and we are left to admire the skill which presided at its formation, and to profit by the instruction which is so impressively conveyed by such mysterious organization."[1]

We have represented in figs. 66 and 67 the figure produced by polarised light by an internal slice of the barrel or cylindrical apophyllite from Kudlisaet, in Disco Island,

[1] Edinburgh Transactions, vol. ix. p. 323.

Polarisation. brought home by Sir Charles Giésècke. The figures are from different specimens. The *shaded part of them has only one axis of double refraction*, while the *four sectors have two axes*, the luminous sectors being analogous to the prisms A, B, C, D, and the dark figure to the central lozenge *abcd*, in fig. 61. The mechanical structure of the cleavage planes resembles the optical figure even after the planes are ground.[1]

Sect. XV.—*On the Absorption of Light by Uncrystallized Bodies.*

When a beam of light passes through the most transparent media, such as air and water, a certain portion of it *is lost*. This loss of light is particularly apparent in such bodies when a beam of light has traversed a great thickness of the gas or the fluid. This loss of light has been called *absorption*, and the light lost is said to be *absorbed;* a term which we use at present as merely expressing a fact.

There are two kinds of absorption which may be noticed. 1. That in which all the rays of the spectrum are proportionally absorbed or lost; and, 2. that in which different quantities of the differently coloured rays are lost. Those bodies in which the first kind of absorption takes place are *colourless*, and those in which the second kind takes place are *coloured*. In black *ink*, for example, the transmitted light of the sun is white. In red ink it is red, more of the most refrangible rays of the spectrum being lost than of the least refrangible ones.

When a beam of the sun's light falls upon a piece of charcoal, the light is almost wholly lost or absorbed. Sir Isaac Newton thought that the light was reflected or refracted "to and fro" within such bodies till it was lost; but still the question meets us, why is it lost? If it is scattered in all directions it must emerge again from the charcoal, and be visible in some way or other. In order to meet this and other difficulties, the light is supposed to be detained within the body, and somehow or other united to its substance.

In the case of red ink and similar bodies Sir Isaac Newton conceived that the *blue* rays which were lost were reflected by the particles of the ink, while the red rays were transmitted, as in the colours of thin plates; but as we cannot by any process see these *blue* rays, we can only say that they are lost, and the cause of their loss is as difficult to be found as in the phenomena of imperfect colourless transparency.

The following are the general phenomena of coloured absorptions in transparent bodies.

1. *Red* transparent solids or fluids absorb, generally speaking, the blue end of the spectrum.

2. *Blue* substances absorb, generally speaking, the red end of the spectrum.

3. *Green* bodies absorb both the blue and the red ends of the spectrum.

4. *Yellow* bodies absorb the *blue* and part of the *green* of the spectrum.

But when we examine more narrowly the action of coloured bodies on the spectrum, we find that a body may derive its peculiar tint from absorbing two, three, four, up to many hundred separate parts of the spectrum, so that the colour of such a body is the combination of all the parts of the spectrum which are not absorbed. We may infer, however, from the general tint of the body, what parts of the spectrum it has chiefly absorbed. *Red nitrous gas*, for example, must have acted most powerfully upon the blue end of the spectrum, as we have already seen that it does. Polarisation.

Three theories of absorption have been recently published, namely, by Sir John Herschel, Baron Wrede, and M. Lamé, all of which are founded upon the undulatory theory. Sir John Herschel. Sir John Herschel conceives that light may be lost within bodies by the interference of different parts of a ray, which, after taking two routes of *different lengths*, meet again in a condition to interfere. This hypothesis has been modified by Mr Whewell in the following manner: "If we conceive," says he,[2] "with Sir John Herschel, a medium which will not transmit vibrations except through certain canals, these canals must have a determinate direction, and therefore such a constitution would give different proportions in different directions. But let a medium consist of certain particles regularly distributed, the intervening space being filled by a medium capable of vibration. Let it be supposed, also, that each vibration, on reaching a medium so disposed, proceeds in part directly and in part by the indirect routes which go *round* some of the particles and rejoin the direct course. We have thus combinations of ramifying and uniting paths, which, though very complex in each direction, are the same in different directions, in consequence of the regular distribution of the particles. If the distribution, though regular, have a reference to certain axes, as in many crystals, the phenomena of absorption may be different in different directions with regard to these axes.

"In this way the theory of ramifying canals comes to coincide with the theory of vibrations, of which parts are differently retarded, and thus interfere with each other; a theory which has been suggested by other authors."

Baron Wrede[3] supposes the particles of a transparent body placed regularly at equal distances, with the ether diffused between them. Baron Wrede. When a ray of light is propagated directly through this medium, a portion of it encounters some of the particles, and is reflected backwards, then forwards again, and emerges along with the direct ray, so that the reflected and direct portions will be in a state to interfere and destroy each other. This theory, which is analogous to Newton's, or rather the very same as Newton's, is liable to the objection we have already urged to every theory in which the light is supposed to be decomposed by interior reflections. Now, Baron Wrede's hypothesis may explain all the phenomena, such as dark bands and dark lines, which are known to be produced by thin plates of various thicknesses, as Dr Young has stated;[4] and it may even explain those bands and absorptions which have been recently discovered in decomposed glass by Sir David Brewster, where the effects are clearly produced by a combination of a great number of thin plates,[5] but where the reflected light is as copious as the transmitted light. But we cannot conceive it at all applicable to the cases of nitrous gas (to which he has attempted to apply it), and to solids and fluids, in which all attempts have failed to discover any of the reflected rays.

The hypothesis of M. Lamé, which we have already stated in our history of Optics, is incompatible with the actual phenomena of absorption. M. Lamé. In place of the lines and bands depending on the surface of emergence, the system of lines is determined by the action of the first surface of the body, a fact independent of all theory.

Of all the theoretical views which we have mentioned, we consider those given by Sir John Herschel and Mr Whewell as the most consistent with observation. They re-

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[1] Edinburgh Transactions, vol. ix. p. 328.
[2] Report of the Fourth Meeting of the British Association, 1834, p. 551.
[3] Taylor's Scientific Memoirs, part iii.
[4] Elements of Natural Philosophy, vol. i. p. 469.
[5] Phil. Trans. 1837, part ii.

Polarisation.

lieve us from the difficulty of accounting for the reflected light; but though they have this in their favour, they are not founded on any direct data, and indeed were brought forward, as Mr Whewell remarks, "to show that there is no incongruity between the undulatory theory and the phenomena of absorption."

Recent inquiries.

An attempt has been recently made by Sir David Brewster to deduce an explanation of absorption, both in uncrystallized and doubly refracting bodies, from direct experiment; but as the details have not been published, we can only at present give a very general notice of it. Having been led to suppose, along with Dr Young,[1] that a transparent medium transmits light in two separate portions, one passing through its ultimate particles, and the other through its pores, and that these portions reunite continually after each successive separation, Sir David Brewster endeavoured so to combine a number of thin plates, that the light transmitted through the whole should move with different velocities, the differences being so small as to produce interference. This task he found to be a very difficult one, but he succeeded, after many failures, in finding a doubly-refracting mineral upon which he could impress this mechanical condition.[2] When he placed a small aperture upon this crystal, in order to exclude as much as possible all the light which had not experienced any change in its velocity, and looked through it at a well-formed prismatic spectrum, or, what was the same thing, analysed the light transmitted by the plate with a good prism, he was astonished at the sight which was presented to him, not only because it confirmed his views on a subject of such high scientific interest, but from the splendour of the phenomena which it displayed. The spectrum was covered with the sharpest bright and dark lines and bands grouped with all the irregularity of the solar and nitrous gas lines. The bright lines of maximum intensity were variously placed; and in almost every spectrum thus formed there was a narrow band of *pure homogeneous* WHITE *light, incapable of being decomposed by prismatic analysis.* But the interest of this result did not stop here. The spectrum of the *ordinary* differed from that of the *extraordinary* ray, and the brightest lines had a different locality in each of them. Here then we have the phenomenon of dichroism, of the absorption of light in crystallized and uncrystallized bodies, and of bright and dark lines and bands in the spectrum, and of the unequal absorption of rays of the same refrangibility, but differing in colour, all displayed by an artificially produced combination, in which we know that the phenomena are owing to the interference of rays differently retarded. It can therefore scarcely be doubted that the varied phenomena of absorption arise from the differences of velocity in the rays which pass through the ultimate particles and through the pores of bodies. The constitution of the body, or the arrangement of the ultimate particles in the first film on which the light is incident, determines the nature of the absorptive action which the body exercises at different thicknesses.

SECT. XVI.—*On Dichroism, and the Absorption of Common and Polarised Light by Doubly Refracting Crystals.*

The name of *dichroism* or *double colours*, was given very appropriately, by M. Cordier, we believe, to a mineral called *iolite*, which in *common light* exhibited two different colours in different directions. Dr Wollaston and several mineralogists had observed this double colour in certain crystals of palladium, tourmaline, and other crystals. The origin of this singular property was not known till Sir David Brewter investigated its origin in *iolite*, and showed that it was connected with the doubly-refracting structure; that it never occurred in the *tessular* crystals which did not possess double refraction. Polarisation.

The connection of dichroism with double refraction, and its general laws, will be understood from the following observations. In a specimen of *yellow Iceland spar* the *extraordinary* image is of an *orange-yellow* colour, while the *ordinary* image is *yellowish-white.* Along the axis of double refraction the colour of the two pencils is exactly the same, and the difference of colour increases with the inclination of the refracted ray to the axis. Hence the difference of colour increases in proportion to the difference of the velocities of the two rays, and is consequently a maximum in the equator of double refraction, and is the same in all parallels; the colour along the axis being the natural colour of the mineral. This is the invariable law of the phenomena in uniaxal crystals. The following are the observations made by the author already referred to.

Colours of the two Images in Crystals with one Axis.

Names of Crystals.	Colour when its Axis is in the Plane of Primitive Polarisation.	Colour when its Axis is Perpendicular at that Plane.
Zircon	Brownish white	A deeper brown
Sapphire	Yellowish green	Blue
Ruby	Pale yellow	Bright pink
Emerald	Yellowish green	Bluish green
Emerald	Bluish green	Yellowish green
Beryl blue	Bluish white	Blue
Beryl green	Whitish	Bluish green
Beryl yellow green	Pale yellow	Pale green
Rock crystal, almost transparent	Whitish	Faint brown
Rock crystal, yellow	Yellowish white	Yellow
Amethyst	Blue	Pink
Amethyst	Grayish white	Ruby red
Amethyst	Reddish yellow	Ruby red
Tourmaline	Greenish white	Bluish green
Rubellite	Reddish white	Faint red
Idocrase	Yellow	Green
Mellite	Yellow	Bluish white
Phos. of lime (lilac)	Bluish	Reddish
———— (olive)	Bluish green	Yellowish green
Phos. of lead	Bright green	Orange yellow
Calcareous spar	Orange yellow	Yellowish white
Octohedrite	Whitish brown	Yellowish brown

Sir John Herschel has found this property beautifully displayed in the sub-oxysulphate of iron, which crystallizes in six-sided prisms. Along the axis the colour is a *deep blood-red*, while through the sides of the prism it is of a *light green* colour. Several tourmalines have also been observed by Sir John to have these same colours along the axis, and at right angles to it. There can be little doubt that this property will be found in every crystal of sufficient thickness that has the property of double refraction. Even if the crystal is colourless, a slight inequality in the intensity of the two images may be observed; and when it is distinctly coloured, the difference of intensity is very easily seen, even when the two colours are not of a different kind.

The phenomena of *dichroism* are best seen in crystals with *two* axes of double refraction, and are well exempli-

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[1] Dr Young made this supposition, not to explain absorption, but to account for the dispersion of colours by refraction. Elem. Nat. Phil. vol. ii. p. 937.

[2] The same property was afterwards found in several crystallized minerals.

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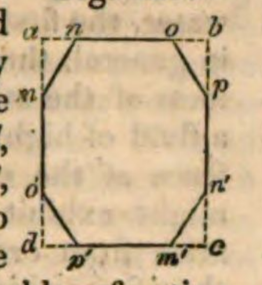
fied in *iolite*, a mineral which crystallizes in six or twelve sided prisms. These prisms are of a *deep blue* colour when seen along the axis, and of a yellowish brown colour when viewed in a direction perpendicular to the axis.

If *abcd* is a section of the prism of iolite in a plane parallel to the axis of the prism, the transmitted light will be *blue* through the faces *ab* and *dc*, and *yellowish-brown* through *ad*, *bc*, and in every direction perpendicular to the axis of the prism. If we grind down the angles *a*, *c*, *b*, *d*, so as to replace them with faces *m n*, *m′ n′*, and *o p*, *o′ p′*, inclined 31° 41′ to *a d*, or to the axis of the prism; then, if the plane *a b c d* passes through the resultant axes of double refraction, we shall observe, by transmitting polarised light through the crystal in the directions *a c*, *b d*, and subsequently analysing it, a system of rings round each of these axes. The system will exhibit the individual rings very plainly if the crystal is thin; but if it is thick, we shall observe, when the plane *a b c d* is perpendicular to the plane of primitive polarisation, *some branches of blue and white light, diverging in the form of a cross from the centre of the system of rings*, or the poles of no polarisation, as shown at *p* and *p′*, fig. 67, where the shaded branches represent the blue ones. The summits of the blue masses at *p* and *p′* are tipped with purple, and are separated by whitish light in some specimens, and yellowish light in others. The white light becomes more blue from *p* and *p′* to *o*, where it is quite *blue*, and more yellow from *p* and *p′* to *c* and *d*, where it is completely *yellow*. When the plane *a b c d* is in the plane of primitive polarisation, the poles *p*, *p′* are marked by spots of white light, but everywhere else the light is a deep blue.

Fig. 159.



In the plane *c a d b*, fig. 159, the mineral, when we look through it at common light, exhibits no other colour but yellow, mixed with a small quantity of blue polarised in an opposite plane. The *ordinary* image at *c* and *d* is yellowish brown, and the *extraordinary* image faint blue, the former receiving some *blue* rays, and the latter some *yellow* ones from *c*, and at *a* and *b*, where the difference of colour is still well marked. The *yellow* image becomes *fainter* from *a* and *b* to *p* and *p′*, till it changes into *blue*, and the faint *blue* image is strengthened by other blue rays, till the intensity of the two blue images is nearly equal. As the incident ray advances from *c* and *d* to *p* and *p′*, the faint blue image becomes more intense, and the *yellow* one, receiving an accession of *blue* rays, becomes of a *bluish white* colour. The ordinary image is *whitish* from *p* and *p′* to *o*, and the extraordinary a *deep blue;* but the whiteness gradually diminishes towards *o*, where they are both almost equally blue.

The principal axis of double refraction in *iolite* is negative. The most refracted image is *purplish blue*, and the least refracted one *yellowish brown*.

The following table shows the *colours* exhibited by crystals with *two* axes:

Colours of the two Images in Crystals with two Axes.

Names of Crystals.	Axis of Prism in the Plane of Primitive Polarisation.	Axis of Prism perpendicular to the Plane of Primitive Polarisation.
Mica	Blood red	Pale greenish yellow
Acetate of copper	Blue	Greenish yellow
Muriate of copper	Greenish white	Blue
Olivine	Bluish green	Greenish yellow
Sphene	Yellow	Bluish
Nitrate of copper	Bluish white	Blue
Chromate of lead	Orange	Blood red
Staurotide	Brownish red	Yellowish white
Chloride of gold and sodium	Lemon yellow	Deep orange
Chloride of gold and ammonia	Lemon yellow	Deep orange
Chloride of gold and potassium	Lemon yellow	Deep orange
Augite	Blood red	Bright green
Anhydrite	Bright pink	Pale yellow
Axinite	Reddish white	Yellowish white
Diallage	Brownish white	White
Sulphur	Yellow	Deeper yellow
Sulph. of strontites	Blue	Bluish white
——— cobalt	Pink	Brick red
Olivine	Brown	Brownish white

In the last eight crystals of the preceding table the tints are not given in relation to any fixed line.

In *Withamite*, a crystal whose principal axis is negative in relation to the axis of the prism, the dichroism is beautiful, and is exhibited both in common and polarised light. When common light is transmitted through the two parallel faces of the prism, the tint is of a crimson or amethyst colour, with a mixture of straw colour. Upon turning the crystal round, the yellow tint disappears, and the colour becomes a deep crimson-red. On continuing to turn the prism, the colour changes to a straw-yellow, and at the end of half a revolution the crystal resumes its compound tint. In the groups of crystals which have penetrated the quartz, some of them occupy accidentally the position which gives the yellow colour, others that which gives the red colour, and some that which gives the compound tint, so that, without a knowledge of their dichroitic property, the group might have been considered as composed of three different sets of crystals.[1]

The following table contains the characters of the two pencils in crystals, the number of whose axes has not yet been determined.

Phosphate of iron	Fine blue	Bluish white
Actynolite	Green	Greenish white
Precious opal	Yellow	Lighter yellow
Serpentine	Dark green	Lighter green
Asbestos	Greenish	Yellowish
Blue carb. of copper	Violet blue	Greenish blue
Orpiment	Sulphur yellow	Lighter yellow

Sir David Brewster found that the dichroism of several crystals is changed by heat, and that in some cases this property may be communicated to them. In several coloured glasses, too, he found an analogous property, when they had received the doubly-refracting structure either temporarily or permanently.[2]

Sect. XVII.—*On the Action of the Surfaces of Crystallized Bodies upon Common and Polarised Light.*

It was remarked by Malus, that the action of the surface of Iceland spar upon light is independent of the position of its principal section, and that its surface acts like that of any common transparent body.[3] In examining,

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Edinburgh Journal of Science, April 1825, vol. ii. p. 219.

[2] See Phil. Trans. 1819, p. 11; or Edin. Philos. Jour. vol. ii. p. 346.

[3] *Théorie de la Double Refraction*, p. 240, 241; and Biot's *Traité de Physique*, tom. iv. p. 339.

Polarisation.

however, the superficial action of this mineral, Sir David Brewster discovered, that all its surfaces, without exception, exercise a remarkable action upon light, and that its polarising angle varied in different azimuths, excepting when the surface was perpendicular to the axis.

If A and A″ are the minimum and maximum polarising angles, viz. in azimuth 0°, or in the plane of the principal section, and in azimuth 90°, or perpendicular to that plane, he found that the variation of the polarising angle was represented by the following expression, where A′ is the polarising angle required at the azimuth a:

$$A' = A + \sin.^2 a\,(A'' - A);$$

in a plane perpendicular to the axis, $A'' - A = 0$, and consequently no change takes place in the polarising angle;

in planes inclined 45° 23′ to the axis on the actual faces of the rhomboid, $A - A = 2°\ 18'$; and

in planes coincident with the axis, $A'' - A = 4°$ nearly.

The following were the measures which our author obtained on the natural faces of the rhomb:

	Polarising Angle.
Azimuth..... 0°	57° 74′
..... 50 57′.....	58 32
.....90	59 32

On faces nearly parallel to the axes:

Azimuth..... 0°.....	54 18
.....90	58 14

Sir David Brewster also observed that the polarisation was more complete in azimuth 0° than in azimuth 90° on the faces of the rhomb; but more complete in azimuth 90° than in azimuth 0° in faces parallel to the axis.

As these experiments clearly proved that the forces which produced double refraction extended beyond the surface of Iceland spar, our author became desirous of ascertaining if the light polarised by reflection from the spar suffered any change from the same cause. He therefore thought of weakening the force which produces reflection, in order to allow the interior force to show its weaker influence; and he accomplished this by placing oil of cassia on its surface, and examining the light reflected at the separating surface of the spar and the oil. The experiments which were thus made, and which are detailed in the Philosophical Transactions for 1819, completely proved that the interior force polarised common light out of the plane of reflection, and modified the law of intensity, according to which light is reflected at different angles of incidence.

These experiments excited no attention till 1835, when Professor Maccullagh, of Trinity College, Dublin, began to investigate the laws which regulate the reflection and refraction of light at the separating surface of two media. He had anticipated from theory effects the reverse of those deduced from the preceding experiments; and in order to account for the latter, he was obliged to modify his theoretical views, and was thus led to the result, that when a ray is polarised by reflection from a doubly-reflecting surface, the plane of polarisation deviates from the plane of incidence, except when the axis lies in the latter plane. The formula which expresses this deviation represents very accurately the measures of the polarising angles in different azimuths in the natural faces of the rhomb, the only surface in which the exception is true; but at all other inclinations of the reflecting planes to the axis, the theory and the formula are in fault, for there is a large deviation when the axis or principal section of the crystal is in the plane of reflection.

Professor Maccullagh's success in deducing theoretically the general fact of a deviation increasing as the refractive power of the medium approached to that of the spar, induced Sir David Brewster to resume his inquiries, the general result of which he communicated to the British Association at Bristol in 1836, in the following very brief abstract.

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"When light is reflected at the separating surface of two media, the lowermost of which is a doubly-refracting one, the reflected ray is exposed to the action of two forces, one of which is the ordinary reflecting force, and the other a force which emanates from the interior of the doubly refracting crystal. When the first medium is air, or even water, the first of these forces overpowers the second; and, in general, the effects of the one are so masked by the effects of the other, that I was obliged to use oil of cassia, a fluid of high refractive power, in order that the interior force of the calcareous spar which I wished to examine might exhibit its effects independently of those which arise from ordinary reflection. The separating surface, therefore, which I used, had a small refractive power; and the reflecting pencil is so attenuated, especially in using polarised light, that it is almost impossible to use any other light than that of the sun.

"When a pencil of common light is reflected from the separating surface of oil of cassia and calcareous spar, the general action of the spar is to polarise a part of the ray in a plane perpendicular to that of reflection, and thus to produce *by reflection the very same effect that other surfaces do by refraction.*

"On the face of calcareous spar, perpendicular to the axis of the crystal, the effect is exactly the same in all azimuths; but in every other face the effect varies in different azimuths, and depends upon the inclination of the face to the axis of double refraction. On the natural face of the rhomb common light is polarised *in the plane* of reflection, in 0° of azimuth, or in the plane of the principal section; but at 38° of azimuth, the whole pencil is polarised at right angles to the plane of reflection; and in other azimuths the effect is nearly the same as I have stated in my printed paper.

"In order, however, to observe the change which is actually produced upon light, it is necessary to use two pencils, one polarised + 45°, and the other — 45°, to the plane of incidence. The planes of polarisation of these pencils are inclined 90° to each other, and the invariable effect of the *new* force is to augment that angle in the same manner as is done by a refracting surface, while the tendency of the ordinary reflective force is to diminish the same angle. Hence I was led to make an experiment in which these opposite forces might compensate one another. I mixed oil of olives and oil of cassia, till I obtained a compound of such a refractive power that its action in bringing together the planes of polarisation should be equal to the action of the new force in separating them. Upon reflecting the compound pencil from this surface, I was delighted to find that the inclination of the planes was still 90°, and I thus obtained the extraordinary result of a reflecting surface which possessed no action whatever upon common or upon polarised light.

"The action of the new force when the plane of reflection coincides with the principal section of the crystal is obviously inexplicable by any theory of light, though I have no doubt that the undulatory theory may ultimately accommodate itself to this as well as to other classes of phenomena which it does not at present embrace. The difficulty, however, is increased by another result of my experiments, which it is important to notice. On the faces of the spar which are inclined 0°, 45°, 90°, to the axis of double refraction, the action of the new force is symmetrical upon the two pencils of polarised light whose planes are inclined + 45° and — 45° to the plane of incidence; whereas in all intermediate faces, whose inclination to the axes is $22\frac{1}{2}°$ and $67\frac{1}{2}°$, the plane of one of the polarised rays remains stationary, while that of the other is turned round 15°.

"This effect is undoubtedly a very extraordinary one, and indicates some singular structure in calcareous spar, the nature of which it is not easy to conjecture.

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"I have examined these phenomena by using, in place of oil of cassia, various fluids whose refractive powers descend gradually to that of water; but it would be a waste of time to give any detailed account of them at present. I shall only state, that the action of the new force becomes weaker and weaker as the force of ordinary reflection is increased, by diminishing the refractive power of the oil which is placed in contact with the spar. With an oil of the highest refractive index, the action of the new force predominates over the feeble power of the ordinary force of reflection. With an oil of a lower index the two forces exactly balance each other; while with oils of still lower indices of refraction, the ordinary force overcomes and conceals the action of the new one.

"Although I have obtained pretty accurate measures of the amount of the deviations produced by the new force, on eight surfaces, differently inclined to the axis, and in various azimuths on these surfaces, yet many experiments are still necessary before we can hope to discover the physical law of the phenomena; and if this should be done, I have no doubt that Mr Maccullagh will be equally successful in the higher attempt of accounting for them by some modification of the undulatory theory."

SECT. XVIII.—*On the Mutual Action of Polarised Rays.*

This curious subject has, we believe, not been studied by any other philosophers but M. Arago and M. Fresnel, and we shall therefore make no apology for giving an account of the results which they obtained, in the words of M. Fresnel himself:[1]—

"In studying the interferences of polarised rays, M. Arago and I found that they no longer exercise any influence upon one another when their planes of polarisation are perpendicular to each other; that is, that they cannot then produce fringes, although all the necessary conditions for their appearance in ordinary cases be scrupulously fulfilled. I shall describe the three principal experiments which illustrate this fact, beginning with that which belongs to M. Arago. It consists in making two pencils, emanating from the same luminous point, and introduced by two parallel slits, traverse two piles of very thin transparent plates, such as those of mica or blown-glass, which are sufficiently inclined to each other to polarise almost completely each of the two pencils, taking care that the two planes are perpendicularly inclined to each other. In this case no fringes can be perceived, whatever care may have been taken thus to compensate the differences of both in varying very gently the inclination of one of the piles; but when the planes of incidence of the piles are no longer perpendicular to each other, they always cause the fringes to appear. In proportion as the planes cease to be parallel, the fringes become weaker, and they disappear altogether when they are rectangular, provided the polarisation of the two pencils has been sufficiently complete. It results from these experiments, that rays polarised in the same plane influence one another, like the rays of light not modified; but this influence diminishes in proportion as the planes of polarisation deviate from one another, and becomes nothing when they are rectangular.

The following is another experiment which leads to the same results. Take a plate of sulphate of lime or of rock-crystal parallel to its axis, and of a uniform thickness; cut it in two, and place each of the halves upon one of the slits of the screen. I suppose that we have turned the two halves in such a way that the edges which were in contact before the division of the plate are parallel, and the axes will also be parallel. But, in this case, we only perceive a single group of fringes in the middle of the bright space as it was before the division of the plates. But, if we turn one of these halves in its plane, thus disturbing the parallelism of their axes, we make two other groups of fainter fringes spring up, situated one on the right, and the other on the left of the group in the middle, and which are completely separated from it, in the white light when the plates of rock-crystal or of sulphate of lime which are used, are only a millimetre thick. It is to be remarked, that the number and breadth of the fringes lying between the middle of one of these groups and the central group, is proportional to the thickness of the plates for crystals of the same kind, or whose double refraction is of the same strength, like rock-crystal and sulphate of lime. In proportion as the angle of the two axes increases, these new groups of fringes become more and more distinct, and attain at last their maximum intensity when the axes of the two plates are perpendicular to each other. In this position, the central group, which had been gradually weakened, altogether disappeared, and is replaced by a uniform light. From this we may conclude, that the rays which produce them, by their interference, are no longer capable of influencing one another.

From the position of these fringes, it is easy to see that they result from the interference of the rays, which have undergone the same kind of refraction in the two plates, since, having travelled with equal velocities, they ought to arrive simultaneously at the middle of the bright space which corresponds to the equal routes, if as we suppose the two plates have the same thickness, and always continue perpendicular to the rays. Hence, the fringes of the central groups were formed by the superposition of those which arise—1. From the interference of the *ordinary* rays of the *left* plate with the *ordinary* ray of the *right* plate; 2. From the interference of the *extraordinary* rays of the *first* plate with the *extraordinary* rays of the *second*. The two eccentric groups, on the contrary, arise from the interference of the rays which have undergone different refractions in the two plates; and as it is the *ordinary* rays which move with the greatest velocity in *sulphate of lime* or *rock-crystal*, we see that, if we employ one of these two species of crystals, the *left* group ought to be formed by the union of the *extraordinary* rays of the *left* plate with the *ordinary* rays of the *right* plate, and the *right* group by the union of the *extraordinary* rays of the *right* plate with the *ordinary* rays of the *left* plate. This being established, it remains now to determine the direction of polarization in each of the pencils which interfere, in order that we may deduce from it what are the relative directions of the planes of polarization which favour or hinder their mutual influence. Analogy shews that the mode of the polarization of light ought to be the same as in the small plates in crystals thick enough to divide it into two distinct pencils. But as this hypothesis might perhaps be an object of discussion, and contradict an ingenious theory of one of our most celebrated philosophers, we shall not present it at first as a certain principle, and we shall have recourse to a direct experiment to determine the planes of polarisation, both of the ordinary and extraordinary rays which emerge from these plates, which we suppose to be one or two millimetres thick. This thickness is sufficient to allow us to cut one of their edges obliquely, and obtain by this prismatic form the separation of the ordinary and extraordinary rays. We then find that they are effectually polarised, the first in the principal section, and the others in a perpendicular direction. If we are not sufficiently convinced that this is their manner of polarisation in emerg-

[1] We have not seen the original Memoir, but have translated this portion of it from M. Pouillet's very valuable work, entitled *Elemens de Physique Experimental et de Meteorologie*, liv. viii. chap. iii.

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ing from each plate when these two surfaces are parallel, we shall find a new demonstration of this in the facts that we are about to describe, setting out from the principles established by the experiments of M. Arago, and which are besides confirmed by others, of which we are going to speak. If, on the contrary, we no longer question the direction of the polarisation of the ordinary and extraordinary rays, actual experiment will afford us a second demonstration of these principles. When the axes, indeed, of the two plates were parallel, the rays which had experienced the same refractions in the two crystals were found polarised in the same direction, and those of contrary colours in rectangular directions. It is thus that the group of fringes in the middle which proceed from the interference of rays of the same name, had a maximum intensity, and the two others, which resulted from the interference of the rays of contrary names, did not appear again. But when the axes of the two plates formed an oblique angle, of 45° for instance, the rays of a contrary name, and those of the same name, could act at the same time one upon the other, since their polarising planes were no longer rectangular, and the three groups of fringes were produced. When, in short, the axes became perpendicular to one another, the rays of the same colour were polarised in rectangular directions, and the central group, to which it had given birth, vanished, while the *ordinary* rays of the *left* plate were then polarised *parallel* to the *extraordinary* rays of the *right* plate, and this is the cause why the right group which they produce attained its maximum intensity. It is the same with the *left* group, arising from the interference of the *ordinary* rays of the *right* plate with the *extraordinary* rays of the *left* plate.

The following is a *third* experiment, which entirely confirms the results which we have drawn from the first. Having polished a rhomb of calcareous spar upon two opposite faces, wrought with care so as to be quite parallel, I sawed it perpendicularly to these faces, and I obtained in this manner two rhombs of equal thickness, and in which the routes of the ordinary and extraordinary rays were exactly parallel at the same incidence. I placed them one before the other, so that the rays proceeding from the luminous point which had traversed the first rhomb passed through the second, taking care that their faces were perpendicular to the direction of the incident rays; moreover, the principal section of the second rhomb was perpendicular to that of the first, in such a manner that the four pencils which they produced were in general reduced to two; the ordinary pencil of the first rhomb was refracted extraordinarily in the second, and the extraordinary pencil of the first was refracted ordinarily in the second. From this arrangement it followed, that the difference of the route, proceeding from the difference of velocity of the ordinary and extraordinary rays, was found compensated for by the two emerging pencils. They crossed each other, too, at a very small angle, and such that the fringes ought to have had a magnitude much more than sufficient to be seen; and, notwithstanding, though the necessary conditions for the production of the fringes, in ordinary circumstances, were carefully observed, I never could succeed in making them appear.

While I was searching for them with care, holding a magnifying-glass to my eye, I gently varied the direction of one of the rhombs, sometimes to the right, sometimes to the left, in order to compensate the effect resulting from any difference of thickness that might have existed; but in spite of this trial, repeated a great many times, I never could perceive any fringes; and this is not surprising, after what the other experiments have taught us, since the two pencils emerged polarised at right angles to each other. But what proves that the absence of fringes does not depend upon the difficulty of arriving by trials at an exact compensation is, that I easily succeeded in making them appear by employing the light which had been polarised before it entered the rhombs, and in causing it to receive a new polarisation after its emergence. It is, then, completely demonstrable from the experiments which I have described, *that rays polarised at right angles cannot exert any sensible influence upon one another;* or in other words, that their union always produced the same intensity of light, whatever may be the difference of route of the two pencils which interfere.

Another remarkable fact is, that when they have been once polarised in rectangular directions, it is not sufficient that they are brought back to a common plane of polarization, in order that they may give apparent signs of their mutual influence. If in the experiment of M. Arago, indeed, or that which I have described, we cause the rays which have emerged from the two slits, and which are polarized at right angles, to pass through a pile of inclined plates of plane glass, no fringes were perceived, in whatever direction its ray of incidence was turned. Instead of a pile, we may employ a rhomb of calcareous spar, if we incline its principal section at 45° to the plane of polarisation of the incident pencils, so that it divides into two equal parts the angle which they make with each other, each image will contain the half of each pencil, and these two halves having the same plane of polarisation in the same image, ought to produce fringes there, if it is sufficient to bring back the rays to a plane of common polarisation, to re-establish the apparent effects of their mutual influence. But the fringes can never be obtained by this method, as long as the rays have not been polarised in the same plane, before they were divided into two pencils polarised at right angles.

When the light has experienced this previous polarisation, on the contrary, the interposition of the rhomb makes the fringes reappear. The most advantageous direction to give the primitive plane of polarisation, is that which divides into two equal parts the angle of the rectangular planes, in which the two pencils are polarised in the second instance, because then the incident light is equally divided between them. Suppose, in order to fix our ideas, that the primitive plane of polarisation is horizontal, it will be necessary that the planes of polarisation impressed upon each of the two pencils, is inclined 45° to the horizontal plane, the one above it and the other below it, in such a manner that they remain perpendicular. We can obtain this rectangular polarisation either with the help of the two little piles employed in the experiment of M. Arago, or with two plates whose axes are rectangular axes, or, finally, with a single crystallized plate: We shall only consider this last case, the two others presenting phenomena precisely similar.

To divide the light into two pencils, which cross under a small angle, and which may thus produce fringes, the apparatus of two mirrors is generally better than the screen pierced by two slits, because it produces more brilliant fringes. It has, besides, the advantage of giving immediately to the two pencils the previous polarisation necessary to our experiment; it is sufficient for this purpose that the two mirrors should be of glass not tinned, and inclined 35° to the incident rays; care must be taken to blacken them behind, to destroy the second reflection. We place near them, in the line of the reflected rays, and perpendicularly to their direction, a plate of sulphate of lime or of rock-crystal parallel to the axis, and one or two millimetres thick, inclining its principal section 45° to the plane of primitive polarisation, which we have supposed horizontal. The apparatus being thus placed, we only see a single group of fringes across the plate as before its interposition, and it occupies the same place. But if we put before the magnifying-glass, a pile of glass plates, inclined in a horizontal or vertical direction, we dis-

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cover on each side of the central group another group of fringes, which is the more distant as the crystallized plate is thicker. If we replace the pile of plates by a rhomb of calcareous spar, whose principal section is divided horizontally or vertically, we shall see in each of the two images which it produces, the two systems of additional fringes which the interposition of the pile of plates has caused to appear; and it deserves to be remarked, that these two images are complementary to one another; that is to say, that the obscure bands of the one correspond to the brilliant bands of the other.

We see in this experiment a new confirmation of the principles demonstrated by the preceding ones. The rays which have experienced the refractions of opposite names, cannot influence each other, because, in emerging from the same plate in the case we are now considering, they are found polarised in rectangular directions; consequently the groups to the right and the left cannot exist, at least while we have not re-established the mutual influence of those rays by bringing them to a common plane of polarisation; this is what is effected by the interposition of the pile of plates or of the rhomb. The fringes thus produced are the more distinct, as the two pencils of contrary names which concur in their formation are more equal in intensity; and this is the reason why the direction of the principal section of the rhomb, which makes an angle of 45° with the axis of the plate, is the most favourable to the appearance of the fringes. When the principal section of the rhomb is parallel or perpendicular to that of the plate, the rays refracted ordinarily by the plate pass entirely into one image, instead of being divided between the two, and all the extraordinary rays pass into the other image, so that there can be no more interference between them; and the additional groups of fringes disappear, each image presenting only the fringes which resulted from the interference of the rays of the same name, that is to say, those which compose the central group.

These two groups of additional fringes which polarized light exhibited in the first position of the rhomb, afford one of the most exact methods of measuring double refraction and of studying its law. Their eccentric position, indeed, depends on the difference of route of the ordinary and extraordinary rays which emerge from the plate; and we can judge of the number of undulations by which the extraordinary rays of the right pencil remain behind the ordinary rays of the left one, by the number and width of the fringes comprised between the middle of the right group, and that of the central group. We may determine this difference of route still better, by measuring the interval between the middle of the two extreme groups, which is the double of their distance from the middle of the central group. White light is best suited for this kind of observations, because it is brightest, and renders the central band of each group easier to be observed. By comparing the thickness of the plate with the difference of the observed route, we may deduce from it the ratio of the velocities of the ordinary and extraordinary rays."

SECT. XIX. — *On the Production of Double Refraction by Heat, Cold, Pressure, and slow and rapid Induration.*

The various phenomena of double refraction and the system of polarised rings, may be produced either transiently or permanently in glass and other substances, by heat and cold, compression and dilatation, and by slow and gradual induration. The phenomena thus produced in polarised light are exceedingly beautiful, and throw much light on the subject of double refraction.

Art. I. *On the Transient Influence of Heat and Cold.*

The influence of heat and cold may be exhibited in *cylinders*, *tubes*, *spheres*, *cubes*, and *rectangular plates* of *glass*, all the phenomena of which were discovered by Sir David Brewster.

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1. *Cylinders of Glass with one axis of double refraction.*

1. *Negative Axis.* — If we take a cylinder of glass, ACBD, fig. 69, from half an inch to an inch in diameter or upwards, about one-half an inch or more in thickness, and transmit heat uniformly from its circumference to its centre, it will exhibit, when placed between the polarising and the analysing plate, and held about eight or ten inches from the eye, the system of uniaxal rings shewn in fig. 69, exactly similar to those in fig. 29; and by turning round the analysing plate, we shall see the complementary set, as in fig. 31, these rings will be seen as if they were in the substance of the glass, and hence, if we cover up any part of the circular surface, we shall cover up a corresponding part of the system of rings. The axis of the system or of double refraction is here fixed in the axis of the cylinder, and does not lie in every direction parallel to that axis, as in regularly crystallized bodies.

The system of rings thus produced is *negative*, like those in *calcareous spar*.

As soon as the heat reaches the axis of the cylinder, the rings become less bright, and they disappear entirely when the heat is uniformly distributed through the glass.

2. *Positive Axis.*—If we heat a similar cylinder of glass uniformly in boiling oil or otherwise, and cool it rapidly at its edges by encircling its margin with a cold and good conducting material, it will exhibit a similar system, which will vanish when the glass is uniformly cold. This system of rings, however, is *positive*, like those of Zircon, and if it is placed above the equal *negative* system, produced as already described, they will destroy each other. If the two systems are not equal, we shall have a system equal to their difference, as in positive and negative uniaxal crystals. In both these systems the tint at any point varies as the square of the distance of that point from the axis, so that if T is the tint at any distance D, the tint t corresponding to any distance d, will be $t = \frac{TD^2}{d^2}$. If V is the velocity of the ordinary ray, we shall have the velocity of the extraordinary ray $v = V^2 + a d^2$.

If we transmit polarized light through the cylindrical surface of these cylinders, we shall observe the phenomena of biaxal systems exactly the same, as in rectangular plates, fig. 81, the tints being produced by the action of the positive or negative axis of the cylinder acting in opposition to an axis passing through each diameter of the cylinder, drawn perpendicular to any point in the middle line of the cylindrical surface.

2. *Oval Cylinders, with two axes of double refraction.*

If we perform the two experiments above described with oval cylinders, as in fig. 70, we shall have a system of rings with two axes. A new axis is developed perpendicular to the axis of the cylinder, and in the case of the heated cylinder the new axis at O is a positive one, while in the cooled cylinder it is a negative one, the neutral black lines AD, CB separating the two classes of tints, and corresponding to the dark hyperbolic branches in biaxal systems of rings. The figure referred to is that shewn in azimuths inclined 45° to the plane of primitive polarization; but in the azimuths of 0° and 90°, the branches AD, CB resume the form of the rectangular cross.

3. *Cubes and Parallelopipeds of glass with double refraction.*

Cubes of Glass. — When the shape of the glass is that of a cube as in fig. 71, the figure which it produces in azimuth 0° by the two processes of heating and

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cooling is that shewn in the figure, the tints being negative or positive according as we apply heat or cold. The complementary system is shewn in fig. 72.

Parallelopipeds of Glass.—In a parallelopiped 0.38 of an inch square, and 1.11 long, the *direct* and *complementary* systems at 0° of azimuth are shewn in fig. 73 and 74. The first of these consist of a black cross, surrounded with beautiful fringes of contrary flexure, and four bright green spots of the third order. The coloured spots at the angles of fig. 74 are of a brilliant pink colour, with a spot of blue in the middle of each. When the azimuth is 45°, the direct and complementary systems change into fig. 75 and 76.

4. *Cylindrical Tubes of Glass with two axes of double refraction.*

When the cylinder has the form of a tube, as in fig. 77, the double refraction is singularly distributed by the application of heat or cold either to the outside ABCD of the cylinder, or to its inside *a b c d*, or to both. A black circular fringe *m n o p*, is the central line which separates the outside or positive structure from the internal negative structure, and *vice versa*. The breadth of the internal annulus *a o* is always less than A *o*, that of the external one. They approach to equality as the bore of the cylinder widens, and the negative structure grows very small, as shewn in fig. 78, when the bore diminishes; so that when the bore becomes infinitely small, the system becomes either wholly negative or positive, according as heat or cold has been used. If when fig. 77 is fully developed, we cut a notch EF in the cylinder, we shall have a biaxal system of fringes in which there is a positive structure between two negative ones, or *vice versa*, as shewn in fig. 79.

The diameter *o p*, fig. 77 and 78, is a geometrical mean between the interior and exterior diameters of the tube, that is $op = \sqrt{(AB \times ab)}$.

5. *Rectangular Plates of Glass, with planes of double refraction.*

If a well annealed parallelopiped of glass EFCD, fig. 80, is submitted to the processes already described, or even if we lay one edge of it CD on a piece of iron almost red hot, and place the whole between the polarizing and analyzing plates, so that if the heated edge CD is inclined 45° to the planes of primitive polarization, and the eye can see the whole surface of the glass, a series of remarkable phenomena will be produced. The moment the heat enters the lower surface at CD, fringes of brilliant colours are seen above CD, and almost at the same instant, before the heat has reached the upper surface EF, or even the central line *a b*, *similar* fringes will appear at EF. Colours, at first faint blue, then white, yellow, orange, red, &c. of the first order spring up at *a b*, and these central colours are separated from those at the edges by two dark lines or planes MN, OP, corresponding to the hyperbolic branches in biaxal crystals, the double refraction between MN and OP being *negative*, in reference to a line perpendicular to the fringes, while it is *positive* without MN and OP. The tints thus developed are those of Newton's scale.

If T is the central tint in the line *a b*, D the distance of either of the lines MN, OP, from *a b*, the tint *t* at any other distance *d*, will be $t = T - \frac{T d^2}{D^2}$, a formula deduced from the opposition of two axes. The term $\frac{T d^2}{D^2}$ represents the influence of the principal axis or axes perpendicular to the line *a b* at every point of it; but as the axis in the plane of the plate produces an uniform tint T, whose maximum is in the line *a b*, where the action of the other axis disappears, and as these axes oppose each other by acting rectangularly, they will compensate each other in the lines MN, OP, and the tint at any point must always be equal to the difference of the tints, or to $T - \frac{T d^2}{D^2}$.

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The magnitude 2 D, or the distance between MN and OP, is a function of the breadth of the plate or *b*, and 2 D: V = 10 : 16.02 and D = .312 B^2.

The fringes seen through the thickness of the plates is shewn in fig. 81, and the one seen through the ends in fig. 82.

If we wish to find the tints in reference to the lines MN, OP, let δ, δ' be the distance of any point from these lines, whose distance from *a b* was *d*, then we have $\delta = 1 - d$, $\delta = 1 - d$ and $\delta\delta' = 1 - d^2$, that is the tint at any point varies, as the product of the distances of that point from the planes of the resultant axes MN, OP. If we make $v^2 = V^2 + \alpha\delta\delta'$, an expression which gives *v* the velocity of the extraordinary ray, we shall have the extraordinary refraction in such plates.

6. *Spheres and Spheroids of Glass with double Refraction.*

Spheres.—If we place a sphere of glass in a glass-trough of hot oil or otherwise heat it regularly, we shall find that when the heat is passing to the centre of the sphere, it will exhibit a positive uniaxal system of rings like that in fig. 69, in every direction in which we transmit the polarized light; that is, it will have an infinite number of *positive* axes of double refraction.

If a hot *sphere* of glass is immersed in a glass-trough of cold oil, a similar system of rings will be produced in every possible direction; but it will be *negative*.

Spheroids. If we substitute *oblate* and *prolate* spheroids in place of the sphere in these experiments, we shall find that they will have each a *positive* system of rings round their axis of revolution. If the polarised light is transmitted through an equatorial diameter, we shall find that there are two axes of double refraction, the black cross opening out when the axis of revolution is inclined 45° to the plane of primitive polarisation.

In the prolate spheroid the black cross opens out in a different plane.

7. *On the Effects produced by combining Plates of Glass under the transient influence of heat and cold.*

If we combine any two plates of the same shape, the resulting system of fringes will be equal to the sum of their systems or effects, if the plates are of the same name, that is, both *positive* or both *negative*, or to the difference of their effects, if they are of different names. When the plates are solids or symmetrical forms, such as cylinders, cubes, or quadrangular plates, no essential variation of figure is produced by the combination; but when the plates are rectangular, very interesting phenomena are exhibited when plates of the same or of different names are crossed rectangularly. Sir David Brewster has given formulæ for calculating the forms of the compound or isochromatic curves, as he calls them, but our space will only permit us to exhibit the effects to the eye.

When equal rectangular plates of *similar names*, that is, both negative or both positive, are crossed, the phenomena of the *intersectional fringes*, as they may be called, are shewn in fig. 83, where the isochromatic curves are *hyperbolas*.

When the plates are of *different names*, the one *positive* and the other *negative*, and of the same breadth, and the same number of fringes, the isochromatic curves are *circles*, as in fig. 84.

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When the plates are of *different names*, and of different breadths, but containing the same number of fringes, the isochromatic curves will be *ellipses*, as in fig. 85.

8. *On the effects produced by altering the form of, or subdividing plates of glass under the influence of heat or cold.*

If we alter the shape of any of the plates above described, the form of the isochromatic curves is immediately changed. If we cut any rectangular plate into two by a line passing through its middle, each of the two plates thus produced has the property of the whole plate, though the fringes are less numerous. If a plate ABCD gives the tints shewn in fig. 86, OP and MN being the dark neutral lines; then if we cut it with a diamond at *a b*, so as to subdivide it into two plates, as in fig. 87, each of the plates EF *r s*, GH *r s*, will have the same structure as ABCD, viz. two neutral lines *o p*, *m n*, and assume positive and negative tints.

Art. II. *On the Permanent Influence of Rapid Cooling.*

In March 1814, Sir David Brewster found that glass melted and suddenly cooled, as in the case of Prince Rupert's drops, possessed a permanently doubly refracting power, and he communicated this fact in a letter to Sir Joseph Banks, dated April 8. 1814; and without knowing that Dr Seebeck had published in December 1814 similar results with cubes of glass, our author had discovered that cubes, cylinders, plates, spheres, and spheroids of glass, exhibiting permanently the phenomena described in the preceding pages, may be formed by bringing them to a red heat, and cooling them rapidly and equally on their edges. A great variety of beautiful optical figures, developed in polarised light, may thus be obtained by cooling the glass on metallic patterns. A very simple effect of this is shewn in fig. 88, where the plate of glass was cooled by resting it at its centre on a cylinder of iron.

Art. III. *On the production of Double Refraction by Compression and Dilatation.*

The effects of compression and dilatation in producing double refraction were discovered by Sir David Brewster, and communicated to the Royal Society in 1815. Our limits will permit us to only give a slight notice of them.

The phenomena both of compression and dilatation or extension may be well seen by bending, merely with the force of the hands, a square rod, or a long and narrow plate of glass, as in fig. 89. When it is held between the polarising and analysing plate, eight or ten inches from the latter, with its edge AB inclined 45° to the plane of primitive polarisation, the whole thickness of the glass will be covered with two series of coloured fringes, like those in the figure separated by a dark neutral line MN, where there is neither compression nor dilatation. The fringes on the convex side are *negative*, being produced by the *extension* of the glass in the direction *m* A, *m* B, while those on the concave side are produced by the *compression* of the glass in the directions C *n*, D *n*. The isochromatic curves marked by similar figures, indicating the orders of the colours, are bent as in the figure.

When a plate of bent glass producing fringes crosses another at right angles, the effect at the intersectional space is shewn in fig. 90, where the tint is supposed only to be the white of the first order.

When a plate of bent glass is crossed with a plate crystallized by heat, the fringes in the intersectional square will be *parabolas*, as shewn in fig. 91, whose vertex will be towards the *convex* side of the bent plate, if the principal axis of the other plate is *positive*, but towards the *concave* side, if that axis is *negative*.

Polarisation.

Art. IV. *On the Double Refraction produced by gradual Induration and difference of Density in soft Solids.*

The phenomena of luminous sectors, separated by a black cross at the central part of the uniaxal system of rings, which Sir David Brewster discovered round cavities in the diamond, in glass, and in various gums, arise from the gradual induration of the mass, combined with the elastic pressure of the air included in the cavities: They are therefore not properly cases of induration alone.

When isinglass is dried in a circular trough, it exhibits, by polarised light, the uniaxal system of rings like glass, in fig. 69.

When it is indurated in the form of a rectangular mass, by the exposure of two sides, fringes are produced parallel to these sides, and biaxal like those in rectangular plates of heated glass.

A sphere of transparent jelly or isinglass, when allowed to indurate gradually, will have an axis of double refraction in every direction, like a sphere of glass heated. In like manner an indurated spheroid will exhibit the biaxal structure of a spheroid of glass.

The most splendid examples, however, of this class of facts are exhibited in the lenses of fishes and animals, as shewn in figs. 92 and 93. The first of these shews the doubly refracting structure of the crystalline lens of a cod, along the axis of vision. The central and the external luminous sectors have a *negative* doubly refracting structure, while the intermediate ones have a *positive* structure.[1]

The figure given by the crystalline lens of a cow is shewn in fig. 93, where there are *four* series of luminous sectors, the central ones being *positive*, the next *negative*, the next *positive*, and the last *negative*.[2]

CHAP. II.—ON CIRCULAR POLARISATION.

1. *Circular Polarisation in Rock-crystal and Amethyst.*

The general phenomena of circular polarisation were discovered by M. Arago in 1811. He found that in plates of rock-crystal, the colours polarised along its axis were different from those which he had studied in plates of other crystallised bodies. When they were analysed by a prism of Iceland spar, he found that the two images had complementary colours in the ordinary tints, but, what was remarkable, they descended in Newton's scale as the prism revolved, so that if the tint of the extraordinary image was *red*, it became in succession *orange*, *yellow*, *green*, and *blue*. Hence he concluded that the differently coloured rays had been polarised in different planes in passing along the axis of the rock-crystal.

M. Biot took up the subject at this point, and investigated it with his usual ingenuity and success. He found that while in *some* crystals of quartz the tints descended in the scale of colours, by turning the analysing prism from *right* to *left*, in *others* they descended in the scale by turning the prism from *left* to *right*. The one he called left-handed quartz, and the other right-handed quartz. He took a plate of quartz, for example, $\frac{1}{23}$th of an inch thick, and having polarised the homogeneous colours of the spectrum, he transmitted them in succession along the axis of this plate, and obtained the following

[1] See *Phil. Trans.*, 1816, p. 311.

[2] See *Phil. Trans.*, 1837, vol. ii.

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results. When the analysing plate was in 0° of azimuth, the *red* light polarised by the plate was a maximum. When the analysing plate was turned from right to left, the *red* tint gradually diminished, and after a rotation of 17½°, it wholly vanished. With a plate 2-25ths of an inch thick, the *red* tint did not vanish till after a rotation of 35°, and so on, every additional 25th of an inch of rock crystal requiring an additional rotation of 17½ to make the tint vanish. A whole inch of quartz, for example, would require 25 × 17½° = 437½°, or one whole turn, and 77½° more to cause the *red* tint to vanish. It is obvious that twenty-five plates of quartz, 1-25th of an inch thick, would produce the same effect as one inch of it.

When *right-handed* plates, however, are combined with *left-handed* ones, the rotation produced is equal to the difference of their actions; thus a plate of left-handed quartz 1-25th of an inch, combined with a plate 2-25ths of an inch, would produce a rotation of only 17½°. The following table contains the rotations produced upon the other coloured rays of the spectrum, as given by M. Biot:—

Names of the ray.	Arc of rotation for 1-25th of an inch in quartz.
Extreme red,	17°·4964
Limit of red and orange,	20 ·4798
Limit of orange and yellow,	22 ·3138
Limit of yellow and green,	25 ·6752
Limit of green and blue,	30 ·0460
Limit of blue and indigo,	34 ·5717
Limit of indigo and violet,	37 ·6829
Extreme violet,	44 ·0827

M. Biot conceived that this property of quartz belonged to its ultimate molecules, but Sir David Brewster proved that this was not the case, by shewing that heat deprived quartz of the property of circular polarisation; and Sir John Herschel's beautiful discovery, that it was connected with the crystallisation of the mineral, put this result beyond a doubt. He found that those crystals in which the plagiedral faces described by Hauy, went round the crystal from *right to left*, exhibited the optical properties of left-handed crystals, and those crystals in which the plagiedral faces leant round the crystals from *left to right*, had the properties of right-handed crystals. Hence he concluded *that whatever be the cause which determined the direction of rotation, the same law acted in determining the direction of the plagiedral faces.*

When Sir David Brewster discovered the system of rings in quartz, he found the tints of circular polarisation occupying, as might have been expected, the inner circle of the rings as shewn in fig. 94, only small portions of the black cross being visible; but these black portions were larger as the plate became thinner.

Fig. 94.

Amethyst.

In examining the structure and properties of the amethyst, Sir David Brewster found that this singular mineral was actually composed of the two different kinds of quartz, viz., the *right-handed* and the *left-handed.* These two kinds of quartz are arranged in veins, as represented in figs. 95, 96. In fig. 95, the shaded veins which correspond to each alternate face of the pyramid turns the planes of polarisation from *right* to *left*, while all the rest of the crystal turns the same planes from *left* to *right;* and what is very interesting, the black lines where these two structures unite have no action whatever on the planes of polarisation. In some specimens these opposite veins are so very minute, that they destroy each other's action upon the polarised ray, and when this happens, the single system of rings appears with its black cross, and entirely free of any of the tints of circular polarisation. The colouring matter of the amethyst is arranged in a very singular manner in relation to these veins; and the fracture across the veins exhibits a beautiful, and sometimes a regular rippled structure, resembling the engine-turning of a watch, and affords an infallible mineralogical character of the amethyst, whether its colour is *yellow, orange, olive, green, blue,* or perfectly colourless.

Figs. 95, 96

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The general structure of well crystallised amethysts is shewn in fig. 96, which is of the natural size, and is taken from one of the finest specimens that Sir David Brewster met with. "On the three alternate sides of the prism," says he, "viz., MN, OP, and QR, are placed sectors M*c*N, O*d*P, Q*a*R, which are divided into two parts by dark lines *cc'*, *dd'*, *aa'*, which separate the direct structures of A, C, and E from the retrograde structures of B, D, and F. On the other three alternate faces of the prisms are placed the three veined sectors M*cba*R, N*cbd*O, and P*dba*Q, which meet at *b* in angles of 120°, and consist of veins of opposite structure, alternating with each other, and so minute, that in many places the circular tints are almost wholly extinguished by their mutual action. The direct sectors A, C, and E, are all connected together by the three radial veins *ba*, *bc*, *bd*, and are therefore to be considered as the expanded terminations of these veins. The retrograde sectors B, D, and F, are expansions of the first retrograde veins next to *bdc*, *dba*, and *abc*, and the lines *cc'*, *dd'*, and *aa'*, are continuations of the dark or neutral lines which separate the first retrograde vein from the direct radial veins.

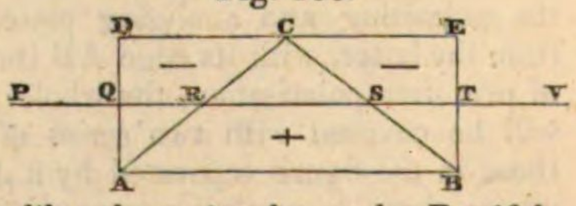
Fig. 96.

"All the sectors A, B, C, D, E, and F, are of a *yellowish brown* colour, and all the rest of the crystal is of a *pale lilac* colour, the lilac tints being arranged in the manner previously described. The phenomena which I have now mentioned as existing in this specimen are very common in the amethyst; and I have never yet found a specimen in which the yellow tints were not confined to those portions which formed the expanded terminations of veins; a fact which indicates that this would have been the colour of the crystal, whether its action were direct or retrograde, and that the lilac colour affects in general those portions which are composed of opposite veins."

Fresnel's discoveries.

The subject of circular polarisation received great accessions from the genius of M. Fresnel. He conceived that a ray passing along the axis of quartz should be refracted in two pencils, and he ascertained this to be the case by the following experiment. He took a prism ACB of *right-handed* quartz, having its faces AC, BC, equally inclined to its axis AB, so that a ray PV should be incident at angles of 75° on either face. As a ray, however, refracted at R, would not emerge at all from the other side CB, he took another similar prism, but from a crystal of *left-handed* quartz, and having cut it into two halves, he placed these two halves ACD, BCE, as in the figure, so that he had an achromatic combination of three prisms. Now a ray PQ incident perpendicularly at Q, should pass straight on without deviation, or double refraction, if quartz were like other uniaxal crystals. But if the pencil PQ suffer any double refraction at Q, this double refraction will be doubled at R, because ABC has an opposite kind of double refraction. The same effect takes place at C, so that the ray PQ at its emergence at T, ought to have a very sensible double refraction, even if that at Q was very small. Now M. Fresnel found that this double refraction actually existed, but upon examining the image he found that they had suffered *a new kind of double refraction*, and acquired new properties. In place of their being polarised in opposite planes, like other doubly refracted pencils, which, when examined with a doubly refracting prism, give two unequal images, alternating in brightness during the revolution of the spar prism, they exhibit the following properties:—

Fig. 160.



1. Either of the quartz rays, when examined with a spar prism, gave two images of equal intensity in every position

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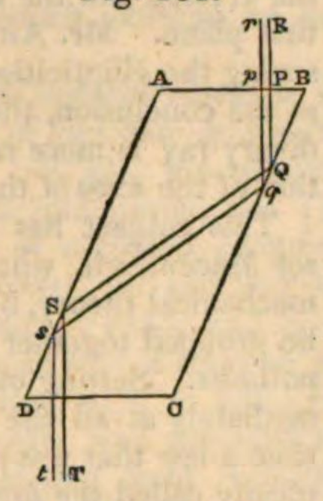
of the prism. Hence they resemble unpolarised light, as if they consisted of two rectangularly polarised rays.

2. They differ from unpolarised light in having the following remarkable and characteristic property. If either of them are incident at right angles, as shewn at RP, fig. 160, upon the face AB of a parallelopiped of crown glass, having its refracting index 1·51, and its angles ABC and ADC 54½°, it will suffer two total reflexions at Q and S, emerging perpendicularly from the surface DC in the direction ST. Now this ray ST is found to be completely polarised in a plane inclined 45° to the plane of its reflexions, whatever may be the position of that plane. If the other ray is incident at *rp*, and is reflected at *q* and *s*, so as to emerge in the direction *st*, the one ray ST will be polarised in a plane 45° to the *right*, and the other *st* 45° to the *left* of the plane of reflexion. Hence they emerge when superimposed in a state of common light. The two rays RP, *rp*, are said to be *circularly polarised*.

Fig. 161.



3. If a ray thus circularly polarised is transmitted through a thin crystallized plate, and parallel to its axis, it is divided by double refraction into two rays of complementary tints, thus shewing a decided difference from a ray of common light; and these complementary colours always differ from those that are produced from light, polarised and analysed in the usual way, by an exact quarter of a tint either in defect or in excess.

4. A circularly polarised ray transmitted again along the axis of rock crystal, and subsequently analysed, produces, like common light, no colours, and differs in this respect from polarised light.

As two circularly polarised rays RP, *rp*, emerge from *Fresnel's rhomb*, (as the parallelopiped of glass ABCD, fig. 160, has been called), in rays ST, *st*, polarised ±45° to the plane of reflection, it occurred to Fresnel, and he found it to be so, that a ray TS polarised 45° to the plane of reflexion in the rhomb, would emerge in the direction PR, as a circularly polarised ray, possessing all the properties of one of the rays formed along the axis of quartz.

Recent experiments.

In an extensive series of experiments, of which we shall give some account in the following chapter, Sir David Brewster had occasion to examine some of the kindred phenomena of circular polarisation. His first experiments on this subject preceded those of Fresnel. He found that total reflexion produced polarised tints analogous to those of crystallised laminæ, and he supposed that these colours were produced by the interference of two portions of light, the one partially reflected in the first instance, and the other beginning to be refracted, and caused to return, by the continued operation of the same power.[1] In continuing his experiments, he found that the colours produced by total reflexion did not rise in the scale by successive reflexions; and at the end of 1816, he announced in the *Journal* of the Royal Institution,[2] that he had discovered "a new species of moveable polarisation, in which the complementary tints never rise above the white (the bluish white) of the first order, by the successive application of the polarising influence," &c. He determined experimentally the angles at which this tint was successively produced and destroyed, and thus discovered some of the leading properties of total reflexion. It was Fresnel, however, that discovered this new species of polarisation to be circular, and made those other splendid discoveries which we have just detailed. We owe to Sir David Brewster, however, the discovery of the inversion of the spectrum in the phenomena of total reflexion, of which we shall give some account in the next chapter.

Circular polarisation

Discovery of Mr. Airy

In giving the name of circular polarisation to that which is impressed on the two rays along the axis of quartz, M. Fresnel was guided by theoretical considerations. Mr. Airy has, however, taken a different view of the condition of the light forming these two rays in quartz, and has been led to results of very high interest. The following are the experiments, which we shall give in his own words, on which he founded his deductions. They were made with a Fresnel's rhomb, fitted up as in the annexed figure, where the rhomb is shewn at *rr*.

Fig. 162.

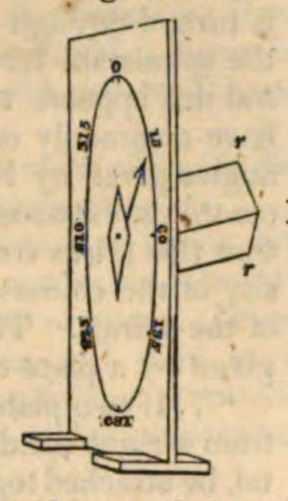


Fig. 97.

"1. If Fresnel's rhomb, mounted as in the annexed figure, be placed to receive the polarised light, so that the plane of reflexion passes through the divisions 45° and 225°, the calc spar will present another appearance 97. The rings are abruptly and absolutely dislocated: those in the upper right hand quadrant and the quadrant opposite to it, are pushed from the centre by one-fourth of an interval, and those in the other quadrants are drawn nearer to the centre by the same quality. The line separating the quadrants is nowhere black; the intensity of its light is uniform, and about equal to the mean intensity. If the plane of incidence pass through 135° and 315°, the phenomena of adjacent quadrants are exactly interchanged. No alteration is made by turning the analysing plate round the incident ray; the lines dividing the quadrants are always parallel and perpendicular to the plane of reflexion at the analysing plate.

"2. If the plane of reflexion in the rhomb pass through 0° and 180°, or through 90° and 360°, the phenomena are precisely the same, and undergo the same changes as those in ordinary rings. If while the plates are crossed, the rhomb be turned gradually from the position 0° towards 45°, the rings are gradually changed, at first becoming (as far as the eye can judge) elliptical, and then assuming the form represented in fig. 98.

Fig. 98.

"3. If a plate of quartz, whether right or left handed, be interposed between the crossed plates, a set of rings is seen like those in fig. 94. As far as the eye can judge, the rings are exactly circular, but there is no black cross, and the central tint is not black, but removed from it by a number of tints in Newton's scale proportional to the thickness of the quartz. Thus with a thickness of 0·48 inch, the central tint is pale pink; with a thickness 0·38 inch, the central tint is bright yellowish green; with thickness 0·26 inch it is a rich red plum colour; with thickness 0·17 inch, it is a rich yellow.

Fig. 94.

"The colours then appear to be nearly the same, beginning from the centre, as in Newton's scale, beginning with the tint representing this central tint. At a considerable distance from the centre, four dark brushes begin to be visible, in the same directions as the arms of the black cross in calc spar.

"4. Now, (supposing the crystal right handed), if the plate of quartz be thin, and the analysing plate be turned, the upper part towards the observer's left hand, a bluish short-armed cross appears in the centre, which, on turning further, becomes yellow, and the rings are enlarged. On turning still further, the cross breaks into four dots. The rings are no longer circular, but of a form intermediate between a circle and a square, their diagonals (as well as the cross) being inclined to the left of the parallel, and perpendicular to the plane of reflexion. See fig. 99. If the analysing plate be turned the other way, there is no cross; the form of the rings is changed from circular nearly as in the former case.

Fig. 99.

"5. If the plate of quartz be thick, the dilatation, and the rings, and the change of form are all the perceptible phe-

[1] See CHROMATICS, vol. vi. p. 646, and *Phil. Trans.* 1830, p. 310.

[2] Vol. iii. p. 213.

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nomena. And on turning the analysing plate continually to the left, the rings continually dilate, and new spots start up continually in the centre, and become rings. If the crystal be left handed, the remarks in this and the last article apply equally well, supposing the analysing plate turned in the opposite direction.

"6. If Fresnel's rhomb be placed in the position 45°, and the light thus circularly polarised pass through the quartz, on applying the analysing plate instead of rings, there are seen two spirals naturally inwrapping each other, as in fig. Fig. 100. 100. If the rhomb be placed in position 135°, the figure is turned through a quadrant. If the quartz be left handed, the spirals are turned in the opposite direction. The central tint appears to be white. With the rhomb which I have commonly used, (which is of plate glass, but with the angles given by Fresnel for crown glass), there is at the centre an extremely dilute tint of pink. I think it likely that this arises from the cross in the angles, as the intensity of the colours have no proportion to that in other parts of the spirals. The figure was drawn from the appearances given by a plate of quartz 0·26 inch thick.

"7. If two plates of quartz of equal thickness, but cut one from a right handed, and the other from a left handed crystal, be attached together, and put between the polarising and analysing plates, the left handed slice nearest to the polarising Fig. 101. plate, the appearance presented is that of fig. 101. Four spirals (proceeding from a black cross in the centre, which is inclined to the plane of reflexion), cut a series of circles at every quadrant. The points of intersection are in the plane of reflexion, and perpendicular to it. This is the simplest way of describing the form; but if we followed the colours which graduate most gently, we should say that the form of each is alternately a spiral and circular arc, quadrant after quadrant.

"At a distance from the centre, the black brushes are seen. If the combination be turned, so that the right handed slice is nearest to the polarising plate, the spirals are turned in the opposite direction. This is one of the most beautiful phenomena of optics. The slices from whose appearance the figure was drawn, are each 0·16 inch thick."

The preceding phenomena are described as they appear when examined with an analysing plate of unsilvered glass. The following are the theoretical views which Mr. Airy considers as consonant with these experiments. They had been originally suggested to him by the desire of finding some connecting link between the peculiar double refraction in quartz, and the common double refraction.

"1. I suppose the ordinary rays to consist of light elliptically polarised, the greater axis of the ellipse being perpendicular to the principal plane, and the extraordinary rays to consist of light elliptically polarised, the greater axis of the ellipse being in the principal plane.

"2. I suppose that when the ordinary ray is right-elliptically polarised, the extraordinary ray is left-elliptically-polarised, and *vice versâ*.

"3. I suppose that the proportions of the axes of the two ellipses are the same, each proportion being one of equality when the direction of the ray coincides with the axis, and becoming more unequal, according to some unknown law, as the direction is more inclined to the axis; the minor axes of the ellipses having sensible magnitudes when the rays are inclined 10° to the axis.

"4. I suppose that the course of the rays after refraction can be determined by the construction given by Huygens for calc spar, with this difference only, that the prolate spheroid for determining the course of the extraordinary ray must not be supposed to touch the sphere for determining the course of the ordinary ray, but must be entirely contained within it."

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In a supplement to his investigations, Mr. Airy remarks, that he has not yet ascertained the law which connects the ellipticity of the rays with the angle that they make with the axis. He considers, however, the following points as made out:—

"One of the rays is certainly right-handed elliptical, and the other certainly left-handed elliptical. The major axis of one is certainly perpendicular to the principal plane of the crystal, and the major axis of the other is certainly in that plane. Mr. Airy remarks, that in some trials for measuring the ellipticities of the rays, he seems to have arrived at the conclusion, that the proportion of the axes of the ordinary ray is more nearly one of equality than the proportion of the axes of the extraordinary ray."

Professor Maccullagh.

This subject has recently been investigated by Professor Maccullagh, whose object was to pave the way for a mechanical theory, by shewing that all the phenomena may be grouped together by means of a simple geometrical hypothesis. Setting out from this hypothesis, he arrives immediately at all the known laws, and obtains at the same time a law that was previously unknown, and which is technically called the *law of ellipticity*. By this law Professor Maccullagh has been able to compute the ellipticities observed by Mr. Airy in rays inclined to the axis of quartz, from the angles of rotation observed by M. Biot in rays parallel to that axis.[1]

The phenomena of circular polarisation were discovered by Sir David Brewster, in plates of glass possessing the doubly refracting structure. M. Dove of Berlin has found it also in compressed glass and has published an interesting memoir on the subject, in which he takes little notice of the previous labours of others, on the various subjects of which he treats. As our limits will not permit us to give any account of its contents, we must refer our readers to the original memoir.[2]

Sect. I.—*On the Circular Polarisation of Fluids.*

Although this remarkable property was discovered in some fluids by M. Seebeck by independent observation, yet M. Biot had anticipated him in it, and has made this subject so completely his own, by a series of the most elaborate and beautiful researches, that if he had done nothing else for science, they would have ensured him a high reputation. We regret extremely that our limits will not permit us to give any thing like a full and satisfactory account of his discoveries, particularly those contained in his valuable paper of 1832. We must therefore refer the reader to his original memoirs, and present to them in as abridged a form as possible his leading results.

M. Biot discovered that some fluids turn the planes of a polarised ray from right to left, and others from left to right. He found also that the tints rose in the scale as in quartz by an increase in the thickness of the fluid. The following table contains some of his results:—

I. *Fluids that turn the Plane of Polarisation from Left to Right.*

	Colours.	Arcs of rotation with the red rays, with a thickness of 200 millimetres.
Oil of fennel seeds	Palish green	26° ·32
——— carraway seeds	Colourless	131 ·58
——— lavender	Greenish	4 ·04
——— rosemary		6 ·58
——— marjoram	Orange yellow	23 ·68
——— sassafras	Yellow	7 ·06
——— savine	Yellow	14 ·12
——— bitter oranges	Greenish yellow	157 ·89
——— bergamot	Colourless	38 ·16
——— lemons	Colourless	110 ·53
Neroli, common	Yellow	$\frac{7}{12}$ths of oil of oranges.
——— fine	Orange yellow	Do.
——— superfine	Reddish or	$\frac{5}{12}$ths of com. Neroli.

[1] Report of the British Association for 1836, p. 18.

[2] This memoir has been translated and published in Taylor's Scientific Memoirs, vol. i. part i. p. 75.

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II. *Fluids that turn the Plane of Polarisation from Right to Left.*

Essential oil of turpentine	Greenish	59°·21
Naphtha	Greenish	15 ·21
Oil of anise seeds	Greenish	1 ·51
——— mint	Limpid	32 ·28
——— rhue	Yellowish	conjectured.

Oil of mustard and oil of *bitter almonds* exercise no action upon polarised light.

Camphor. M. Biot found that in a solution of *natural camphor* in alcohol, in which there was 0·37117 of camphor in weight to I of the solution, and its density 0·87221, the rotation for *red* light, and a thickness of 152 millimetres, was 17° ·56 from *left to right.* A solution of *artificial camphor* in alcohol, on the other hand, with 0·0917 of camphor to of the solution, and having its density 0·8455, and in a thickness of 1357 millimetres, produced only a rotation of 24°, but in the opposite direction, from *right to left.* In *gum from Senegal,* of which 47·4 parts was dissolved in 99·1 of distilled water there was a rotation from right to left, of 12° 13′ 20″, with a thickness of 152 millimetres.

The following table contains the results which our author obtained from different kinds of sugar :—

From Left to Right.

	Proportion of sugar in 1 of the solution.	Density.	Arc of rotation of red light in a thickness of 152 millimeters.	Molecular power of rotation.
Sugar of canes, syrup of..	0·25	1·1052	23° 28 45	
———	0·50	1·2311	52 7 30	83° 94
———	0·65	1·3114	70 11 15	
Sugar of milk	0·14	1·0537	10 21 40	70·18
——— Starch	0·65	1·2460	48 30 0	59·99
Crystallisable principle of honey	0·34	1·1329	16 47 30	43·32
Sugar of grapes				59·10

From right to left.

The rotation being observed for the yellow rays, and the thickness of solution 152 millimeters as before.

Sugar of grapes in syrup	10° 0′ 0″
Uncrystallisable principle of honey, alcoholic solution	3 38 20
——— the same dry	11 15 0

M. Biot made experiments with various vegetable juices, all of which gave a slight rotation from *right to left.*

	Thickness of fluid.	Rotation.
Juice of grapes white	160 millimetres	6°
Do. red and white mixed	160 ———	·6·25
Chasselas	160 ———	5·50
Muscat	160 ———	5·33
Verjuice	160 ———	1·81
Chasselas of Fountainbleau	160 ———	8·00
Common black grape	160 ———	10·00
Apples for cider	———	3·33
Red gooseberries very ripe	80 ———	1·81
Berries of the service tree	160 ———	2·5

M. Biot also found, that claret, white champagne, alcohol, sulphuric ether, citric acid dissolved in the proportion of 30 to 37 of water, sulphuric acid pure and colourless, and olive oil, produced no effect upon polarised light.

He found, however, that tartaric acid dissolved in the proportion of 53 of acid to 52 of water produced a rotation of 8° *from right to left.*

Dextrine. One of the most curious discoveries contained in M. Biot's memoir, is that of the powerful rotatory property of *dextrine* an uncrystallisable syrup which is found in the farina of rice, wheat, and even of ligneous tissue.[1] It differs from gum in producing an opposite rotation, and from sugar in its superior power of rotation, which is almost triple of that which is exerted by sugar of canes. It surpasses all animal and vegetable substances at present known, at equal densities and thicknesses, in turning round the plane of a polarised ray,— rock crystal only being superior to it. The name of dextrine has been given to it in order to mark the direction as well as the powerful energy of its force of rotation. Elliptical polarisation

M. Biot and M. Persoz have more recently found a sugar of starch, whose power of rotation is almost equal to that of crystallised sugar of canes. They have also discovered that, when sugar of canes is dissolved in water mixed with dilute sulphuric acid, and heated below the boiling point, it loses its power of turning the planes of polarisation from left to right, like sugar of grapes not solidified. Sugar of starch submitted to the same process did not experience this inversion.

M. Biot likewise found, that the colouration of liquids did not exercise any influence on their rotatory property.

We regret that want of room prevents us from giving any account of M. Biot's more recent, and extremely interesting researches on the growth and nutrition of plants. These researches have a high practical value, and shew in a striking manner that the most abstract researches in physical science will sooner or later find some useful application.

CHAP. III.—ON ELLIPTICAL POLARISATION.

The phenomena and laws of elliptical polarisation, as they are at present known, have been investigated only by Sir David Brewster. This species of polarisation forms the connecting link between *plane polarisation* and *circular polarisation,* passing nearly into the former when exhibited by *galæna* and into the latter when exhibited by *silver.*

Sir David Brewster found at an early period, what Malus had previously observed, that the light reflected from metals was polarised in different planes. The former, however, found, that the pencil polarised in the plane of reflexion was always more intense than that polarised in a perpendicular plane, and which he conceived had entered the metal and been partially absorbed. He found the difference between the intensities of these pencils to be least in silver and greatest in galæna, metals which had an intermediate effect, being arranged as in the following table.

Order in which the metals polarise most light in the plane of reflexion.

Galæna.	Steel.	Copper.	Fine gold.
Lead.	Zinc.	Tin plate.	Common silver.
Grey cobalt.	Speculum metal.	Brass.	Pure silver.
Arsenical cobalt.	Platinum.	Grain tin.	Total reflexion
Iron pyrites.	Bismuth.	Jewellers' gold.	from glass.
Antimony.	Mercury.		

He found also that, by increasing the number of reflexions, *the whole of the light could be polarised in one plane.* The white light of a wax candle 10 feet distant, is polarised by *eight* reflexions from *steel* between 60° and 80°, whereas it requires more than *thirty-six* from *silver,* and in total reflexion where the elliptical polarisation becomes circular; and when the two pencils are equal, the total polarisation of the pencil cannot be effected by any number of reflexions.

The action of metals upon polarised light presents us with a series of very extraordinary phenomena. One of the first of these which was discovered by our author, was the action of successive reflections from silver and gold upon polarised light. These reflexions are made from two metallic plates placed between the polarising and analysing plate or rhomb, and when the plane of metallic reflexions is parallel or perpendicular to the plane of primitive polarisation, its

[1] Dextrine may be procured from laundry starch by hot or cold acids, by potash, or by hot water, any one of which will rupture the envelope and set free the dextrine.

Elliptical polarisation

azimuth will be 0°, 90°, 180°, &c. and when it is inclined 45° to that plane, its azimuth will be 45°, 135°, &c.

In azimuth 0° no colours are observed by reflexions from two plates of silver placed parallel to one another, just as in the case of crystallised laminæ whose axes are in 0° of azimuth.

At 45°, 135° of azimuth, the most brilliant complementary colours are seen, either by turning round the analysing plate, or by using a rhomb of spar that gives two images. These colours become fainter and fainter while the azimuth changes from 45° to 90°, or from 45° back to 0°, exactly like those of crystallised laminæ.

When a small number of reflexions are used, the tints are fainter and less brilliant, and they increase with the number of reflexions. There is an angle of reflexion about 75°, at which the tints are brightest, and they become fainter as the reflexions are performed at greater or at less angles.

All the other metals in the preceding table, as well as total reflexion from glass, give analogous colours, but they are most brilliant in silver, and diminish towards galæna.

Now, it is obvious, that at about 75° of incidence (if we suppose the metal to be steel) the polarised light which it reflects has acquired some new physical property.

1. It is neither *common light* nor *partially polarised* light, because if we reflect it a second time at 75° *it is restored* to light polarised in one plane.

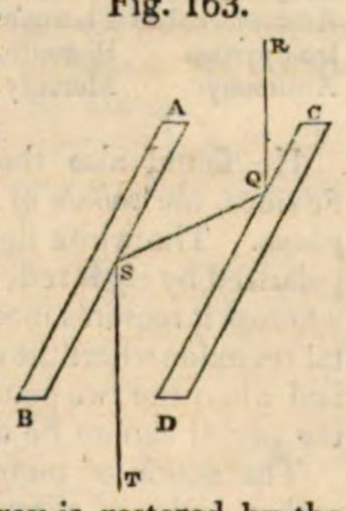
2. It is not polarised light, because it does not vanish during the revolution of the analysing rhomb.

In order then to discover its nature, let it be transmitted along the axis of Iceland spar. The common uniaxal system of rings is changed into that shewn in fig. 102, which is similar to the effect produced by crossing the uniaxal system of rings with a thin film polarising the pale blue of the first order. If we substitute for the Iceland spar, films of sulphate of lime, we shall find that their tints are increased or diminished according as the metallic action coincides with or opposes that of the crystal. This experiment led our author into the erroneous opinion that metals acted like crystallised plates; but when he found that a second reflexion at 75° destroyed the effect of the first reflexion, he saw that this opinion was untenable, and was led to consider the phenomena as having some resemblance to those of circular polarisation.

We have already seen, that a circularly polarised ray RP, fig. 161, emerges after two total reflexions in the direction ST, polarised 45° to the plane of the two reflexions in every azimuth. Now, if we reflect a ray of light R polarised +45° at Q from one plate of *silver* CD, the rays QS will have acquired a property analogous to that of circular polarisation; for if it is reflected a second time at S, the reflected ray ST will emerge polarised 39° 48′ to the plane of reflexion. Now the difference between this result and that from total reflexion, is that one reflexion from silver impresses the same character upon light, whereas in total reflexion two reflexions are necessary. Another point of difference is, that when the ray is restored by the same number of reflexions, it is not wholly restored to a plane —45°, but only to a plane —39° 48′. But there is another difference of a very interesting kind. In circular polarisation, the ray has the same properties on all its sides, and the angles of reflexion at which it is restored to polarised light in different azimuths, are all equal to the radii of a circle described round the rays. "Hence," says our author, "without any theoretical reference the term *circular polarisation* is from this and other facts experimentally appropriate.[1] In like manner, *without referring to the theoretical existence of elliptical vibrations* produced by the interference of two rectilineal vibrations of unequal amplitudes, we may give to the new phenomenon the name of *elliptic polarisation*, because the angles of reflexion at which this kind of light is restored to polarised light, may be represented by the variable radius of an ellipse."

Elliptical polarisation

Fig. 163.



Now, it is a curious fact, that while silver restores the ray to angles of 39° 48′, other metals restore it to angles deviating more and more from 45°, as is shewn in the following table:

	Inclination of restored ray			Inclination of restored ray.	
Total reflexion from glass	45°	0′	Bismuth	21°	0′
Pure silver	39	48	Speculum metal	21	0
Common silver	36	0	Zinc	19	10
Fine gold	35	0	Steel	17	0
Jewellers' gold	33	0	Iron pyrites	14	0
Grain tin	33	0	Antimony	16	15
Brass	32	0	Arsenical cobalt	13	0
Tin plate	31	0	Cobalt	12	30
Copper	29	0	Lead	11	0
Mercury	26	0	Galæna	2	0
Platina	22	0	Specular iron	0	0

Hence it appears that the elliptic polarisation passes into circular nearly in the case of *silver*, and into plane polarisation in the case of *galæna;* the ellipsis becoming nearly a *circle* in the former case, and a *straight* line in the latter.

As light polarised + 45° suffers different degrees of elliptical polarisation by one reflexion from metals, and is restored again to polarised light, though in different planes, by a second reflexion, so it exhibits the same phenomena at 3, 5, 7, 9 in reflexions, and is restored to polarised light by 4, 6, 8, 10 reflexions at the same angle. The following table shews the inclination of the plane of polarisation of the restored ray to the plane of reflexion, in various numbers of reflexions from silver and steel.

Number of Reflexions.	Inclination of the plane of the polarised ray. Steel.			Silver.		
2	—	17°	0′	—	38°	15′
4	+	5	22	+	31	52
6	—	1	38	—	26	6
8	+	0	30	+	21	7
10	—	0	9	—	16	56
12	+	0	3	+	13	30
18	—	0	0	—	6	42
36		0	0	+	0	47

These results shew in the clearest manner the reason why common light is polarised by 8 reflexions from *steel*, and not till after 36 reflexions from silver, the planes of inclination of the two rectangularly polarised rays requiring in each case that number of reflexions to bring them into a state of parallelism.

The angles at which elliptical polarisation is produced by one reflexion, may be regarded in the present state of our knowledge of the subject as the angle of maximum polarisation, and its tangent as the index of refraction of the metal, as given in the following table:

Name of metal.	Angles of maximum polarisation.		Index of refraction.
Grain tin	78°	30′	4·915
Mercury	78	27	4·893
Galæna	78	10	4·773
Iron pyrites	77	30	4·511
Grey cobalt	76	56	4·309
Speculum metal	76	0	4·011
Antimony melted	75	25	3·844
Steel	75	0	3·732
Bismuth	74	50	3·689
Pure silver	73	0	3·271
Zinc	72	30	3·172
Tin plate hammered	70	50	2·879
Jewellers' gold	70	45	2·864

[1] See Sir John Herschel's *Treatise on Light*, § 1050.

Elliptical polarisation

We may produce elliptical polarisation by a sufficient number of reflexions at any given angle, in the same manner as in plane polarisation. The following table contains the results of observations made with *steel :*

Number of reflexions at which elliptical polarisation is produced.	Number of reflexions at which the pencil is restored to a single plane.	Observed angle of incidence.
3 9 15, &c.....	6 12 18, &c.....	86° 0′
2½ 7½ 12½, &c.....	5 10 15, &c.....	84 0
2 6 10, &c.....	4 8 12, &c.....	82 20
1½ 4½ 7½, &c.....	3 6 9, &c.....	79 0
1 3 5, &c.....	2 4 6, &c.....	75 0
1½ 4½ 7½, &c.....	3 6 9, &c.....	67 40
2 6 10, &c.....	4 8 12, &c.....	60 20
2½ 7½ 12½, &c.....	5 10 15, &c.....	56 25
3 9 15, &c.....	6 12 18, &c.....	52 20

At an incidence of 67° 40′ elliptical polarisation is produced by 1½, 4½, 7½ reflexions. Hence we draw the interesting conclusion, that the ray must have completed its elliptical polarisation in the middle of the *second* and *fifth* reflexion ; that is, when it had reached its greatest depth within the metallic surface. It then begins to resume its state of polarisation in a single plane, and recovers it at the end of the 3d, 5th, and 7th reflexion. Another very interesting effect is produced when one reflexion is made on one side of the polarising angle, and the other reflexion on the other side. A ray that has been partially elliptically polarised by one reflexion at 85° does not as in plane polarisation acquire more by a reflexion at 54°, but it retraces its course, and recovers its state of single polarisation.

We have seen that by *two* reflexions, there is only *one* angle, viz. 73° for silver, at which the elliptically polarised ray can be restored to plane polarisation. At *three* reflexions there are *two* angles, viz. 63° 43′, and 79° 40′, at which the restoration can take place, at *four* reflexions *three* angles, and so on. This phenomena is exhibited to the eye in fig. 103, where the concentric arches I, I ; II, II, &c., represent the quadrant of incidence from *one*, *two*, &c. reflexions, B being the point of 90° and C that of 0°. The point D on the line A is the point or line of maximum elliptic polarisation, viz. 73° for silver, and the figures 1, 2, 3, 4, 5, indicate the points or nodes of restoration, and their distances from C, the corresponding angles of incidence at which the restoration takes place. The loops or double curves lying between the points 1, 2, 3, &c. are drawn to give an idea of the intensity of the elliptic polarisation which has its minimum at 1, 2, 3, &c. and its maximum at the white intermediate parts. These points of maximum intensity do not bisect the loops, or are not equidistant from the minima ; but such is their relation that the *maximum* for *n* reflexions is the minimum for 2*n* reflexions. These phenomena lead us to the explanation and analysis of the complementary colours which accompany elliptical and circular polarisation.

Fig. 103.

On the Colours of Elliptical and Circular Polarisation.

When the preceding experiments are made with homogeneous light, we find that the points and angles of restoration vary for the differently coloured rays. Thus in *silver* we have the maximum polarising angle as follows :

		Corresponding index of refraction.
For red light.....	75½	3·866
For yellow light.....	73	3·271
For blue light.....	70½	2·824

Hence it is obvious that at the point of restoration where the *blue* rays are restored, and vanish, the *red* rays are not restored, and consequently will appear when the principal section of the analysing rhomb is in the plane of reflexion. Here, then, we have the cause of the phenomena of the complementary colours seen in reflexion from metals. They are analogous to the colours in *oil of cassia*, and *chromate of lead* at the maximum polarising angle.[1]

Elliptical polarisation

Fig. 103.

But the remarkable result of the preceding measures is, that in *metallic* as well as in *total reflexion*, the *index of refraction is less for blue than for red light*, or in the language of the undulatory theory, the refractive index increases with the length of the wave. In a recent communication to the Royal Irish Academy,[2] on the propagation of light in uncrystallized media, Professor Lloyd has obtained an expression for the velocity of the propagation of light, each of its terms consisting of two parts with opposite signs, one of which is due to the action of the ether and the other to that of the body. Conceiving, therefore, that there may be bodies in which the principal term is nearly nothing, the principal part of the expression will be that derived from the second term ; and if that term be taken as an approximate value, it will follow that the refractive index of the substance must be in the subduplicate ratio of the length of the wave nearly. "Now," says Professor Lloyd, "it is remarkable that this law of dispersion, so unlike any thing observed in transparent media, agrees pretty nearly with the results obtained by Sir David Brewster in some of the metals. In all these bodies, the refractive index (inferred from the angle of maximum polarisation) increases with the length of the wave. Its values for the *red*, *mean*, and *blue*, ray in *silver*, are 3·866, 3·271, 2·824, the ratios of the second and third to the first being .85 and .73. According to the law above given, these ratios should be .88 and .79."

Professor Maccullagh has very recently[3] endeavoured to represent the phenomena described in the preceding pages by empirical formulæ, in the same manner as Fresnel represented those of total reflexion. The following is a brief abstract of Professor Maccullagh's researches, which we shall give in his own words.

"The author observes, that the theory of the action of metals upon light is among the *desiderata* of physical optics, whatever information we possess upon this subject being derived from the experiments of Sir David Brewster. But, in the absence of a real theory, it is important that we should be able to represent the phenomena by means of empirical formulæ ; and accordingly, the author has endeavoured to obtain such formulæ by a method analogous to that which Fresnel employed in the case of total reflexion at the surface of a rarer medium, and which, as is well known, depends on a peculiar interpretation of the sign $\sqrt{-1}$. For the case of metallic reflexion, the author assumes that the velocity of propagation in the metal, or the reciprocal of the refractive index, is of the form

$$m\,(\cos.\,\chi + \sqrt{-1}\,\sin.\chi)\,;$$

without attaching to this form any physical signification, but using it rather as a means of introducing two constants (for there must be two constants, m and χ, for each metal) into Fresnel's formulæ for ordinary reflexion, which contain only one constant, namely, the refractive index.

"Then if i be the angle of incidence on the metal, and i' the angle of refraction, we have

$$\sin.\,i' = m\,(\cos.\,\chi + \sqrt{-1}\,\sin.\,\chi)\,\sin.\,i, \qquad (1)$$

and therefore we may put

$$\cos.\,i' = m'\,(\cos.\,\chi' - \sqrt{-1}\,\sin.\,\chi')\,\cos.\,i, \qquad (2)$$

$$\text{if} \quad m'^4\cos.^4 i = 1 - 2m^2\cos.2\chi\sin.^2 i + m^4\sin.^4 i, \qquad (3)$$

$$\text{and} \quad \tan.2\chi' = \frac{m^2\sin.2\chi\sin.^2 i}{1 - m^2\cos.2\chi\sin.^2 i}. \qquad (4)$$

"Now, first, if the incident light be polarised in the plan,

[1] For a full analysis of these phenomena, see *Phil. Trans.* for 1830, p. 319.

[2] Jan. 9, 1837.

[3] Proceedings of Royal Irish Academy, Oct. 24, 1836.

Elliptical polarisation

of reflexion, and if the preceding values of sin. i', cos. i', be substituted in Fresnel's expression

$$\frac{\sin.\,(i-i')}{\sin.\,(i+i')},$$

for the amplitude of the reflected vibration, the result may be reduced to the form

$$a\,(\cos.\,\delta - \sqrt{-1}\,\sin.\,\delta), \tag{5}$$

if we put

$$\tan\psi = \frac{m}{m'}, \tag{6}$$

$$\tan\,\delta = \tan\,2\psi \sin\,(\chi+\chi') \tag{7}$$

$$a^2 = \frac{1-\sin\,2\psi\cos\,(\chi+\chi')}{1+\sin\,2\psi\cos\,(\chi+\chi')}. \tag{8}$$

Then according to the interpretation, before alluded to, of $\sqrt{-1}$, the angle δ will denote the *change of phase*, or the retardation of the reflected light; and a will be the amplitude of the reflected vibration, that of the incident vibration being unity. The values of m', χ', for any angle of incidence, are found by formulæ (3), (4), the quantities m, χ, being given for each metal. The angle χ' is very small, and may in general be neglected.

"Secondly, when the incident light is polarised perpendicularly to the plane of reflexion, the expression

$$\frac{\tan\,(i-i')}{\tan\,(i+i)}$$

treated in the same manner, will become

$$a'(\cos\,\delta' - \sqrt{-1}\,\sin\,\delta') \tag{9}$$

if we make

$$\tan\,\psi' = mm', \tag{10}$$

$$\tan\,\delta' = \tan\,2\psi' \sin\,(\chi-\chi'), \tag{11}$$

$$a'^2 = \frac{1-\sin\,2\psi'\cos\,(\chi-\chi')}{1+\sin\,2\psi'\cos\,(\chi-\chi')}; \tag{12}$$

and here, as before, δ' will be the retardation of the reflected light, and a' the amplitude of its vibration.

"The number $\text{M} = \frac{1}{m}$ may be called the *modulus*, and the angle χ the *characteristic* of the metal. The modulus is something less than the tangent of the angle which Sir David Brewster has called the *maximum polarising angle*. After two reflections at this angle, a ray originally polarised in a plane inclined 45° to that of reflexion, will again be plane polarised in a plane inclined at a certain angle ϕ (which is 17° for steel) to the plane of reflexion; and we must have

$$\tan\,\phi = \frac{a'^2}{a^2} \tag{13}$$

Also, at the maximum polarising angle we must have

$$\delta' - \delta = 90° \tag{14}$$

And these two conditions will enable us to determine the constants M and χ for any metal, when we know its maximum polarising angle and the value of ϕ; both of which have been found for a great number of metals by Sir David Brewster. The following table is computed for steel, taking $\text{M} = 3\frac{1}{2}$, $\chi = 54°$.

	δ	δ	a^2	a'^2	$\frac{1}{2}(a^2+a'^2)$
0°	27°	27°	·526	·526	·526
30	23	31	·575	·475	.525
45	19	38	·638	·407	·522
60	13	54	·729	·308	·518
75	7	98	·850	·240	·545
85	2	152	·947	·491	·719
90	0	180	1·	1·	1·

Elliptical polarisation

"The most remarkable thing in this table is the last column, which gives the intensity of the light reflected when common light is incident. The intensity *decreases* very slowly up to a large angle of incidence, (less than 75°,) and then increases up to 90°, where there is total reflexion. This singular fact, that the intensity decreases with the obliquity of incidence, was discovered by Mr. Potter,[1] whose experiments extend as far as an incidence of 70°. Whether the subsequent increase which appears from the table indicates a real phenomenon, or arises from an error in the empirical formulæ, cannot be determined without more experiments. It should be observed, however, that in these very oblique incidences Fresnel's formulæ for transparent media do not represent the actual phenomena for such media, a great quantity of the light being stopped, when the formulæ give a reflexion, very nearly total.

"The value of $\delta'-\delta$, or the difference of phase, increases from 0° to 180°. When a plane-polarised ray is twice reflected from a metal, it will still be plane-polarized if the sum of the values of $\delta'-\delta$ for the two angles of incidence be equal to 180°.

"It appears from the formulæ, that when the characteristic χ is very small, the value of δ' will continue very small up to the neighbourhood of the polarising angle. It will pass through 90°, when $mm'=1$; after which the change will be very rapid, and the value of δ' will soon rise to nearly 180°. This is exactly the phenomenon which Mr. Airy observed in the diamond.

"Another set of phenomena to which the author has applied his formulæ are those of the coloured rings formed between a glass lens and a metallic reflector; and he has thus been enabled to account for the singular appearances described by M. Arago in the *Memoires d'Arcueil*, tom. 3, particularly the succession of changes which are observed when common light is incident, the intrusion of a new ring, &c. But there is one curious appearance which he does not find described by any former author. It is this. Through the last twenty or thirty degrees of incidence the first dark ring, surrounding the central spot, which is comparatively bright, remains constantly of the same magnitude; although the other rings, like Newton's rings formed between two glass lenses, dilate greatly with the obliquity of incidence. This appearance was observed at the same time by Professor Lloyd. The explanation is easy. It depends simply on this circumstance, (which is evident from the table,) that the angle $180°-\delta'$, at these oblique incidences, is nearly proportional to cos. i.

"As to the index of refraction in metals, the author conjectures that it is equal to $\frac{\text{M}}{\cos\,\chi}$."

Undulatory theory.

In concluding our account of the phenomena of Physical Optics, we could have wished to have given a popular account of the undulatory theory of light, and of the explanation which it affords of a great variety of the most interesting phenomena in optics. This however has been done to such an extent by Dr. Thomas Young, in the article CHROMATICS in this work, and in the article POLARISATION by M. Arago, that we would not be justified in entering again upon the subject. Notwithstanding, however, its acknowledged power in accounting for such a variety of facts, there are many of the principal phenomena in optics of which it is not capable of giving the least explanation; and there are others to which it seems in its present form to be totally inapplicable. We look forward, however, with much hope, to the labours of Professor Lloyd, and Professor Maccullagh, and Professor Powell, in this country, who, in place of checking the progress of enquiry, as has been lately done, by declaring the theory of undulations to be

[1] See *Edinburgh Journal of Science, N. S.* Oct. 1830, vol. iii. p. 278.

Explanation of natural phenomena.

already capable of explaining every phenomenon, regard it as still imperfect even as a mathematical representation of the phenomena, and consider experimental research as the only means by which a true theory of light can be obtained.

PART VIII. ON THE APPLICATION OF OPTICS TO THE EXPLANATION OF NATURAL PHENOMENA.

As several of the subjects which belong to this branch of Optics have been treated pretty fully in other parts of this work, we must confine our attention to topics which have not been previously discussed.

SECT. I.—*On the Rainbow.*

Rainbow.

A general description of the rainbow has already been given among the optical phenomena in METEOROLOGY. In order to explain the progress of the rays of light which form the two bows, let R, R, R, R, fig. 104, be parallel rays proceeding from the sun, situated at the back of the observer, placed at O, and let them fall on drops of rain E, F, G, H, in front of the observer. Some of these rays of light will enter the spherical drops of rain, and those which fall perpendicularly and nearly so, will be transmitted through the drop, and of course never reach the observer at O. Other rays, however, especially those which fall obliquely, will be separated into the prismatic colours at the first refraction, and will subsequently be reflected *once*, *twice*, and more times, within the drop, and emerge after *one*, *two*, or more reflexions in different directions. Now, it is obvious that there will be some position of the drops, such as E, F, at which rays that have suffered *one* reflexion will reach the eye of the observer at O. Drops above these will throw the rays which they refract after one reflexion above O, and drops below these will throw the same rays below O. In like manner, there must be some position, as at H and G, at which other drops in which the light that has suffered two reflexions will fall upon the eye at O, the drops above these throwing the rays above, and the drops below them throwing the rays below O. Now, each drop forms by refraction a prismatic spectrum, or coloured and elongated image of the sun. The rays RE, RF, which reach the eye at O, must fall upon the lower drops E, F, on their upper side, as shewn in the figure, and consequently (as may be found by tracing the rays through the drops) the spectrum which they form will have the red rays uppermost, as at *r*, near F, and the *violet* rays downwards, as at *v*, near E; and as the same effect will be produced from all the other drops which reflect the sun's rays to the point O, there will appear to an eye at O, a coloured bow, such as we see it in the heavens, with all the colours of the spectrum, as if they had been formed from the sun's image, by a prism of water that produced the same degree of refraction. In like manner, the rays that enter the lower side of the drops will form an inverted spectrum, after *two* reflexions, in which the *red* rays are below, and the *violet* ones above, and as this spectrum is much fainter, it will give a second coloured bow, fainter than the first, and having its red side below, and its violet side above. The following are the dimensions of the two bows:—

Fig. 104.

Radius of the *red* edge of the *inner* bow....	42°	2′
..... *violet* edge	40	17
Breadth of the inner bow.....	1	45
Radius of the *violet* edge of the *outer* bow	54	7
..... *red*.....	50	57
Breadth of the outer bow.....	3	10
Distance between the bows.....	8	55

Dr. Halley has shewn that the solar rays which suffer *three* reflexions, will form a bow round the sun at the distance of 40° 28′, and that those which suffer *four* reflexions will form a bow at the distance of 45° 33′ from the sun; but the light which reaches the eye after so many reflexions is too faint to be seen, and these bows have consequently never been discovered.

Explanation of natural phenomena.

Supernumerary *bows* of red and green light, to the number of *three*, have been seen in contact with the violet arch of the inner bow, and we have seen them also on the outside of the outer or secondary bow. The cause of these is not known, but a very ingenious explanation of them has been given in CHROMATICS, vol. xi. p. 634, sect. iii.

Sir David Brewster, upon examining the two rainbows with a rhomb of Iceland spar, found that they consisted wholly of *light polarised* in the plane of reflexion within the drop, or in planes coincident with the radii of the bow. The two bows present a case of *conical polarisation*, the part of the bow vanishing as the principal section of the rhomb becomes parallel to its radius. It is strange that the polarisation of the bow, and consequently of light, had not been discovered when it happened to be seen by reflexion on panes of glass, or other reflecting substances, lying with their planes of reflexion perpendicular to the planes of reflexion within the drop, and near the angle of maximum polarisation. See METEOROLOGY, vol. xiv. p. 749.

SECT. II.—*On Halos and Parhelia.*

The name of *halos* and *parhelia* have been given to circles round the sun and moon, some of which are extremely complicated and beautiful. The general theory of this class of phenomena has been given by Dr. Young, in the article CHROMATICS, vol. vi. p. 634, sect. ii., and a description of the phenomena themselves, in the article METEOROLOGY, vol. xiv. p. 749.

Artificial halos.

The production of halos, which have their origin in the refraction and reflexion of crystals of ice floating in the atmosphere, may be illustrated by the following method given by Sir David Brewster. A few drops of a saturated solution of alum spread over a plate of glass, so as to crystallise rapidly, will cover the glass with an imperfect crust, which is composed, when examined by the microscope, of flat octohedral crystals, scarcely visible to the eye. If the observer places his eye behind this plate, and close to its smooth side, he will see the sun or the candle encircled with three fine halos, placed at different distances. The interior one, which is the whitest, is formed by the refraction of the rays through two of the faces that have the least inclination to each other, and consequently give a spectrum in which the colours are not greatly dispersed; and as a similar pair of refracting planes lie in every direction, there will be a spectrum in every direction, and consequently a rainbow of a circular form. The second halo, which is *blue* without and *red* within, with all the intermediate prismatic colours more highly dispersed, is formed by a pair of faces more inclined. The third halo, which is larger and more brilliantly coloured, is produced by a third pair of refracting planes, having a greater refracting power, and consequently giving a higher dispersion. When the granular crystals have double refraction, and when they crystallise with their axes perpendicular to the plates, combinations of greater variety and beauty will be produced.

We have endeavoured, by looking through hoar frost upon glass, to produce halos actually resembling those seen in nature; but we have not succeeded, though we have no doubt that it may be effected by causing vapour deposited under a variety of circumstances, to be frozen in different ways.

SECT. III.—*On the Unusual Refraction of the Atmosphere.*

One of the most interesting applications of optical science

Explanation of natural phenomena.

is the explanation which it affords of the extraordinary phenomena which arise from difference of density in different parts of the atmosphere. As this subject has been treated very fully in our article METEOROLOGY, vol. xiv., and illustrated with some interesting figures, we shall confine ourselves at present to an account of the most extraordinary of all the phenomena of this kind which have been observed and correctly described. It was observed by Dr. Vince, on the 6th of August 1806, about seven o'clock in the evening. Between Ramsgate and Dover there is a hill, over which the tops of the four turrets of Dover castle are usually seen to a person at Ramsgate. At the time above mentioned, however, Dr. Vince, when at Ramsgate, not only saw the four turrets *v*, *x*, *w*, *y*, but the *whole of the castle*, *m*, *n*, *s*, *r*, appearing as if it were situated on the side of the hill next to Ramsgate, and rising as much above the hill AB as usual, *as if it had been brought over and placed on the Ramsgate side of the hill*, fig. 105. This appearance continued about twenty minutes. Between Ramsgate and the land from which the hill rises, there is about six miles of sea, and from thence to the top of the hill about the same distance, the height of the eye above the surface of the sea being about seventy feet. It is a very singular circumstance in this phenomenon, that the image of the castle was so very strong and well defined that the hill itself did not appear through the image.

Fig. 105.

In order to explain this phenomenon, Dr. Vince supposes AB, fig. 106, to represent the castle, FC the cliff of Ramsgate, BTD the hill, DC the sea, E the place of the spectator, T the top of the hill, A*yv*E a ray of light coming from the top of the castle to the observer, and B*xw*E another ray coming from the bottom of the castle, and T*xz*E a ray from the summit of the hill, reaching the eye at E, in a direction between those of the other two rays; then it is obvious that such a disposition of the rays will produce the observed appearance. In order to give such a refraction, the density of the air between *yv*E and *xw*E must have varied with great rapidity, so as to increase the curvature of the ray T*xz*E, after it cuts B*w*E in *x*, in order to make the ray T*xz*E fall between the other two rays. See *Edinburgh Transactions*, vol. vi. p. 245.

Fig. 106.

SECT. IV.—*On the Colours of the Atmosphere.*

Colours of the atmosphere.

As the earth's atmosphere acts upon light like all other transparent bodies, and is continually changing its chemical, mechanical, and hygrometrical condition, it acts upon light in very different ways, under different circumstances. As the colour of the sky is absolutely black on the tops of the highest mountains, its blue colour in the regions which we inhabit is owing to the action of the atmosphere.

That the *blue* light of the sky is light that has suffered reflexion from the particles of our atmosphere, is proved by the fact observed by Sir David Brewster, that this blue light is polarized in a plane passing through the observer's eye and the sun. This fact is well illustrated by the discovery which we owe to the same author, of *atmospheric lines* in the spectrum, formed by the blue sky. These lines are principally in the more refrangible spaces, as already described, and hence the prevailing light is blue.

The splendid colours which mark the rising and the setting of the sun, varying from the deepest *red* to *orange*, *yellow*, and even *green*, arise from the same cause; for when we analyse these various lights with the prism, we find that they are owing to definite parts of the spectrum having been absorbed by the atmosphere.

Blue shadows.

The phenomenon of blue shadows is finely seen when the sky is particularly blue. It arises solely from the shadows being illuminated by the blue sky, while the part round the shadow is illuminated by the sun, or by the light of a candle. If the light of the sun passes at the time through vapours so as to make it yellow or orange, the contrast of the shadow is still more striking and beautiful. The light of a candle which contains a great excess of red light, and which may be made to contain more by letting it burn with a long wick, exhibits along with the light of the sky the phenomenon of blue shadows in great perfection.

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The subject of the blue colour of the sky has been treated at considerable length in our article on METEOROLOGY, vol. xiv. p. 760, and an instrument called a *Cyanometer*, for measuring its blue colour, has been well described, and an account of the experiments made with it fully detailed.

SECT. V.—*On the Colours of Natural Bodies.*

Colours of natural bodies.

The splendid colours which appear in the natural world have long attracted the attention of philosophers; but no person ever had the courage to give a philosophical theory of them but Sir Isaac Newton. When he had completed his analysis of the colours of thin plates, he conceived that they furnished the true cause of the colours of natural bodies. If we take a thin film of mica, a few millionths of an inch in thickness, it appears to the eye of a bright blue colour. Sir Isaac Newton maintained, that if this film could be cut into a great number of minute parts of the same thickness as itself, these particles would "keep their colour, and a heap of them constitute a mass or powder of the same colour which the plate exhibited before it was broken." A plate of mica of a different thickness, would be *green*, another *yellow*, and another *red*, and all these, if broken down into particles "of the same thickness with the plates," would of course, according to our author, give a *green*, a *yellow*, or a *red* mass.

We have already seen that different thickness of a transparent plate like mica, give various orders of colours; each different tint corresponding with a particular thickness. Considering then the particles of all bodies whatever as transparent, and as having different sizes, they will produce colours corresponding to these different sizes, and consequently we shall have as great a variety of tints in nature as there are varieties in the sizes of the particles of bodies. A difficulty, however, here presents itself. The colours arising from thin plates vary rapidly by inclining them to the incident light, whereas those of coloured media suffer no such change. Hence Sir Isaac Newton, was driven to the supposition that the particles of bodies have such an enormous refractive power, that the paths of the rays refracted by a parallel film will not differ much in length from, and consequently not be very oblique to, a perpendicular line. After explaining this theory, Sir Isaac ventures to affix to different natural colours the order to which they belong, the very tint of that order, and consequently the thickness of the particles which produce the colour. He says, for example, that the *green* colour of all vegetables, the most general tint in nature, is a GREEN of the *third* order, and that the *blue* colour of the sky is a *blue* of the *first* order. Now we know the composition of a *green* of the *third* order, and of a *blue* of the *first* order, as given by Sir Isaac Newton himself. The *green* of the *third* order "is principally constituted of *original green*, but not without a mixture of some *blue* and *yellow*;" that is, it consists of all the rays of the green space, with the least refrangible rays of the *blue* space, and the most refrangible rays of the *yellow* space, and it does not contain a single ray of *indigo*, *violet*, *orange*, or *red* light.

Such being the case, it occurred to Sir David Brewster that the green colour of plants could be accurately analysed by the prism, and having extracted by means of alcohol the green juice of a great variety of vegetable bodies, he analysed their colours by the prism. In all bodies he found the composition of this green colour to be identically the same; but it had no relation whatever to the *green* of the first order. It contained portions of all the colours of the

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spectrum; and the prismatic spectrum seen through these green juices was divided unequally into *six* luminous bands of various breadths, separated by dark intervals.[1] In the same manner he found that the *blue* colour of the sky was not a *blue* of the *first* order.

From a series of experiments in which the same author has been engaged, he has been led to the conclusion that absorption is the cause of this extensive class of colours; and that all the colours of natural bodies arise from the interference of light, by which certain rays are extinguished. When the interference takes place as in thin plates, between the light reflected from the two surfaces, and between the direct transmitted ray and other transmitted rays which suffer reflexion within the thin plates, we have two colours complementary to each other; but even in this case, when the number of films is great, as in decomposed glass, the transmitted colours lose all their resemblance to the colours of thin plates, while the reflected tints are exceedingly brilliant and metallic in their lustre.[2]

In coloured fluids and coloured glasses, and coloured gaseous media, the interference arises from rays that acquire different velocities in passing through the coloured medium, one part of the intromitted light passing through the particles, and the other through the intervening spaces. Hence there are no reflected tints in such coloured media.

Those who wish to study the Newtonian theory of the colours of natural bodies, are referred to Biot's *Traité de Physique*,[3] where it is illustrated and defended with all the sagacity and talent of that distinguished philosopher. See also an account of various ingenious experiments hostile to the theory, in a paper by Mr. Delaval in the *Manchester Memoirs*, vol. ii. p. 131.

Sect. V.—*On the Eye and on Vision.*

In our article on Anatomy,[4] we have already given a full description of the organ of vision, and Plate XXXIII, fig. 3, exhibits a fine section of the eye after Soemmering. The following dimensions of the eye have been given by Dr. Thomas Young, the measures being taken with great care from his own eye:

	Hundredths of an inch.
Length of optical axis	91
Vertical chord of the cornea	45
Versed sine of ditto	11
Horizontal chord of the cornea	49
Aperture of the pupil seen through the cornea	27 to 13
Diminished in consequence of the magnifying power of the cornea	25 to 12
Radius of the anterior surface of the crystalline lens	30
Radius of the posterior surface	22
Distance of the optical centre from the anterior surface of the lens	10
Distance of the optical centre of the lens from the cornea	22
Focal length of the cornea for objects 10 inches distant	115
Joint focus of cornea and lens 91—22=	69
Principal focal distance of lens	173
Distance of the centre of the optic nerve from the point opposite the pupil	11
Range of the eye, or field of vision	110

The following measures of the crystalline lens and cornea were taken by Sir David Brewster and Dr. Gordon, from the eye of a female, above fifty years of age, a few hours after death.

	Index of Refraction.
Diameter of the crystalline	0·378
Diameter of the cornea	0·400
Thickness of the crystalline	0·172
Thickness of the cornea	0·042

The following measures of the refractive powers of the humours of the eye, were taken by the same authors from the same eye:

	Index of Refraction.
Refractive power of water	1·3358
Ditto of aqueous humour	1·3366
Ditto of vitreous humour	1·3394
Ditto of outer coat of crystalline	1·3767
Ditto of middle coat of ditto	1·3786
Ditto of central part of ditto	1·3990
Ditto of the whole crystalline	1·3839

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The following measures may be occasionally useful:

	Index of Refraction.
From aqueous humour into the crystalline	1·0466
Do. do., taking the mean index of the crystalline,	1·0353
From the crystalline into the vitreous humour	0·930

Vision. If we execute a large diagram of the eye, and by means of the above indices of refraction trace the progress of parallel rays from the cornea to the retina, we shall find that they converge to points in or near to that membrane. The increase of density in the crystalline lens towards its centre is calculated to correct the spherical aberration, by bringing the central rays to the same focus with the marginal rays; but there is no provision in the eye for correcting the aberration of colour, because the purposes of vision do not require it to be corrected. It may be readily proved by tracing the rays diverging from both extremities of any object to the retina, and it may be also shewn by direct experiment, that an inverted image of the object is formed upon that membrane. Now, it is a law of vision, that when a ray of light falls upon any point of the retina, the mind infers that the ray proceeded from a point in some line perpendicular to that point of the retina. Hence, as rays from the upper part of an object fall upon the lower part of the retina, and *vice versâ*, such rays will seem to proceed from the upper part of the object, and all points of an object will be seen in the direction of the rays which issue from them, and consequently the object itself *must* appear *erect*, though its image is inverted.

Cause of erect vision

Single vision with two eyes. As it is a law of vision that an object seen with a single eye is seen in a fixed direction, arising from the form of the retina as a whole, or from the form of its individual parts, then if rays from the same object fall upon another eye, or upon a hundred other eyes which have the power of placing the retina of all the eyes, so as to see the same object in the same direction, then the object thus seen must appear single. The only difference will be, that the object will be seen twice as bright with two eyes, and a hundred times as bright with an hundred eyes. If we place a hundred shillings in the same straight line, an eye whose axis coincides with the axis of the cylinder which they compose, will only see one shilling, and the same effect would be produced if the shillings were transparent. If the hundred eyes were placed with their axes in a hundred different directions, an hundred objects will be seen. Small objects are seen double and even triple with one eye when the crystalline lens is not uniform in its refractive power.

Origin of squinting. The defect of squinting may arise from several causes. It may be an original defect, in which the *axis of the eye*, or the line in which objects are seen most distinctly does not pass through the centre of the pupil. In this case it is incurable: but it is generally speaking a disease arising from an imperfection in one eye, from its having a different focal length from the other, from its giving a less distinct vision of objects, or from its muscles not being able to direct it as quickly as the other to visible objects. The consequence of this is, that as the observer can do without it, and uses only his best eye, the imperfect one does not follow the movements of the other, and therefore squints.

Indistinctness of oblique vision. When we wish to see any object very distinctly, we invariably direct to it the axis of the eye, and it is a curious fact that there is no retina at the point where the axis meets the back of the eye, the *foramen centrale* corresponding to the

[1] See *Edinburgh Transactions*, vol. xii. [2] *Phil. Trans.* 1837, p. 245. [3] Tom. iv. p. 123. [4] Vol. ii. p. 798.

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extremity of the axis. When the eye thus sees an object with perfect distinctness, every other point of the same object is seen indistinctly, and there is no adjustment of the eye by which distinctness of vision can be obtained at any distance from the axis of the eye, the only way of seeing disinctly being to direct the axis to the point we wish to examine. The preceding fact leads to the opinion, that parts of an object seen in the retina cannot be seen distinctly, and yet if this were the case, we should be able to perceive upon an uniform ground the *foramen centrale*.

Indistinct vision at the base of the optic nerve.

The opinion that the retina, though sensible to light, does not give perfectly distinct vision, is favoured by the fact, that when the image of any object falls upon the round base of the optic nerve, shewn in Plate XXXIII. fig. 3 of ANATOMY, the object is not distinctly visible. This may be easily proved by fixing on the wall of a room, at the height of the eye, three wafers each *two* feet distant. Stand in front of the middle wafer with one eye shut, and beginning near the wall, withdraw gradually from it, (continuing to view the *left* hand wafer if the *right* eye is open, and the *right* hand wafer if the *left* eye is open,) till the middle wafer vanishes. This will be found to take place at *five* times the distance from the wall at which the wafers are placed, that is, at the distance of *ten* feet in the present case. If we use three candles, the middle one will not vanish like the wafer, but will become a cloudy mass of light.

Occasional insensibility of the retina in oblique vision.

The occasional insensibility of the retina to objects seen obliquely, was discovered by Sir David Brewster, who has illustrated it in the following manner. If we fix one eye on a particular point, such as the head of a pin stuck into a green cloth, and lay down a quill or strip of paper upon the green cloth, some inches distant from the pin, and then keep looking steadily at the pin's head, part of the quill, or the whole of it, will occasionally disappear, as if it had been wholly removed from the cloth. In a short time it will reappear, and again vanish. The very same effect is produced, though less readily, when both eyes are used, and when a luminous body is used in place of the quill. In this case the luminous body does not disappear, but expands into a mass of nebulous light, which is of a *bluish white* colour, encircled with a bright ring of *yellow* light.

Superior brightness of objects seen obliquely.

But though we cannot see objects distinctly by oblique vision, yet they appear much brighter, and minute objects, especially luminous ones, are more easily seen by turning the axis of the eye away from them. Various astronomers have found that very faint stars, and the satellites of Saturn, which disappear when the eye is turned fully upon them, may be distinctly seen by directing the eye to another part of the field. This effect seems to arise from the expansion and enlargement of luminous points seen obliquely.[1]

On the seat of vision.

It has long been disputed, but the question has not been much agitated in modern times, whether the retina or the choroid coat behind it is the seat of vision. The insensibility of the base of the optic nerve, and the fact that vision is most distinct where there is no retina, are arguments in favour of the choroid coat being the seat of vision, as Mariotte believed. The transparency of the retina, and the opacity of the choroid coat were considered as additional arguments in favour of that opinion. Dr. Knox has shewn, that in the eye of the cuttle fish, there is a membranous opaque pigment in front of the retina, so that in this case the retina must receive the influence of light from the vibrations of this membrane just as it may receive them in other cases, from the same membrane placed behind it. M. Lehot, a living French author, has endeavoured to shew that the vitreous humour is the seat of vision; that we see the length, breadth, and thickness of every object as we do an image formed in smoke; and that the retina takes cognizance of this image in its three dimensions, by nervous filaments extending so far into the vitreous humour as to render any adjustment of the eye at different distances unnecessary.

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Insensibility of the eye to direct impressions of faint light.

The insensibility of the retina to direct impressions of faint light, was discovered by Sir David Brewster,[2] who found, that when the eye directed its axis to objects faintly illuminated, it could not keep up a sustained vision of them. They disappeared and reappeared, and the eye was thrown into a state of painful agitation.

Duration of impressions on the retina.

When we shut the eye quickly after looking at an object, we see it for an instant (about the *seventh* part of a second) in its own colours; but this impression is instantly followed by an image of the object in its complementary colours. If we look at a window at the end of a long passage, we first see, after shutting our eyes, a picture of the window, with *black* bars and *white* panes; but after the *seventh* of a second the picture is one with *white* bars and *black* panes. When we whirl a burning stick, we see a complete circle of red light, although the burning end of the stick can only be in one part of the circle at the same instant. This affection of the retina is the principle of Dr. Paris's pretty toy, called the *Thaumatrope*, or *Wonder-turner*. A circular card with two strings is made to whirl rapidly round one of its diameters. If we draw a cage on one side of a card, and a bird on the other, and whirl the card round, we shall see the bird within the cage, the retina retaining the impression of both even when none of them are seen, which is the case when the edge of the card is directed to the eye.

Dr. Paris' thaumatrope.

Phenakistoscope, or magic disc.

The same property of the retina to preserve impressions of light, is the principle on which that beautiful instrument, called the phenakistoscope, or magic disc, is founded. This instrument was, we believe, originally invented by Dr. Roget, and improved by M. Plateau, at Brussels, and Mr. Faraday. It consists of a circular disc from six to twelve inches in diameter, with rectilineal apertures on its margin in the direction of its radii. A series of figures, of a rider for example, leaping a fence, is drawn on the circumference of a circle, parallel to the rim of the disc. The *first* figure represents the rider and horse standing *before* the fence; and the *last* figure represents them standing *over* the fence when the leap is completed. Between these two figures there are several others, representing the rider and the horse in different parts of the leap. The observer then stands in front of a looking-glass, with the disc in his left hand, attached to a handle, and by a piece of simple mechanism he whirls it rapidly round, looking at its image on the glass through the notches in its margin. He is then surprised to see the horse and his rider actually leaping the fence, as if they were alive, and returning and leaping again as the disc revolves. If we look over the margin of the disc, at the reflected picture on the face of the disc, all the figures are effaced, and entirely invisible; but when we look through the notches, we only see the figure of the horse and rider at the instant the notch or aperture passes the eye, so that the picture instantaneously formed on the retina is not obliterated by preceding or subsequent impressions. Hence the eye receives in succession the pictures of the horse and rider in all the attitudes of the leap, which are blended, as it were, into one action. The apparent velocity with which the horse and rider advances (supposing the disc always to have the same velocity) depends on the proportion between the number of apertures in the margin of the disc, and the number of figures of the horse and rider.

If we use a disc with three concentric circles of apertures, each containing different numbers, 8, 10, and 12, for example, then considering that these apertures revolve in the opposite direction in the reflected image, it is obvious that when we look through the circle of 10, which moves from left to right at the image of 10, revolving in the mirror from right to left, these opposite motions will de-

[1] See *Lond. and Edin. Phil. Mag.* Sept. 1832, p. 169.

[2] *Edinburgh Journal of Science*, No. vi. p. 288.

Explanation of natural phenomena.

stroy each other, and the circle of 10 apertures will appear to stand still in the picture. On the other hand, the circle of 12 apertures will always gain upon the one of 10, from which we look, and will appear to move from left to right, with the difference of the velocities of the two, while the one of 8 will move backwards with the same difference.

If we whirl a disc containing any word or figure upon it, without using a reflector, all is confused, and we cannot read the word or see the figure. Let it be whirled, however, in the dark, and let a spark of electricity, or the light of a little inflamed gun-powder, or of a percussion-cap, illuminate the disc, which it does only for an instant, and during that short instant, the word or figure will be seen to stop, and we shall read the one and see the other with great distinctness.

Accommodation of the eye to different distances.

When objects are placed at different distances, the focus or point of distinct vision in the eye must vary. We feel that the eye has the power of adapting itself to these different distances, so as to make the picture on the retina always distinct. How this is done has been long a matter in dispute. There can be no doubt, however, that the first step in the process is the variation of the pupil, which seems by a mechanism at the base of the iris to increase the distance of the lens from the retina.

Longsightedness.

At the age of about forty, the eye loses this power of adaptation in consequence of the flattening of the crystalline lens, which renders it necessary to use a convex glass, which just compensates the flatness of the lens, and permits the eye to adjust itself as formerly.

Shortsightedness.

The opposite state of the eye, not produced by age, but rather diminished by it, is common even in young persons, arising either from a too great convexity or refractive power in the lens, or too great convexity in the cornea. In this state of the eye, the image is formed in front of the retina, and a concave lens is necessary to correct it. This is called *short-sightedness*, which almost always decreases by age in consequence of the crystalline lens becoming flatter.

Ocular spectra, or accidental colours.

When the eye looks steadily at a bright coloured *red* wafer, and then looks at the white paper on which the wafer lies, it will see for a while a *green* one, the green being the *accidental* colour, or the *complementary* one to the *red*. The *green* image is called an *ocular spectrum*, as it has no real existence. The *accidental colours* and the original colours are the same as those given in Newton's Table, p. 432, where the *reflected* tints correspond with the original or *red* colour of the wafer, and the *transmitted* ones to the accidental colour, or *vice versa*; so that we can determine from that table the accidental colours of any coloured object upon which the eye may look steadily.

When the eye looks at the sun, or a bright image of it, the ocular spectrum is not *black*, but of various colours in succession, each colour being surrounded with a rim of its accidental colour.

Colours produced by the unequal action of light on the eyes.

The following beautiful experiment, shewing the effect of light in diminishing the sensibility of the retina to particular colours, we owe to Mr. Smith, surgeon at Fochabers. Hold a slip of white paper vertically about a foot from the eye, and direct both eyes to an object beyond it, the slip will appear double, and the two images equally white. Let a candle be brought near the right eye, so as to act strongly upon it, without affecting the left, then the *left* image of the paper, or that seen by the right eye, will grow *green*, and the *right* hand image, or that seen by the *left* eye, will grow *red*, forming a beautiful contrast of colours. If the candle is brought round to the left eye, the images will first become of the same whitish colour, and then the *right* hand one will become *green*, and the left hand one *red*.[1]

Insensibility of the eye to particular colours.

The insensibility of the eye to particular colours is very uncommon. Professor Dugald Stewart, Dr. Dalton, and Mr. Troughton, were unable to distinguish the colours at the red end of the spectrum. All red objects appeared green, owing to the insensibility of their retinas to red colours. This subject has already been treated of in our article on COLOURS, vol. vii. p. 128.

Optical instruments.

PART IX. DESCRIPTION OF OPTICAL INSTRUMENTS.

Optical instruments.

The great number of optical instruments which have been described in different parts of this work, renders it scarcely necessary to treat this subject in the general article. Under the articles BURNING INSTRUMENTS, CAMERA LUCIDA, KALEIDOSCOPE, MICROMETER, MICROSCOPE, PHOTOMETERS, and TELESCOPE, the reader will find the information, some of which he might have expected here. There are instruments, however, so intimately connected with Optics, and not previously described, which we must shortly notice, namely, the *Cylindrical Mirror*, the *Camera Obscura*, the *Magic Lantern*, and the *Phantasmagoric Machine*.

1. *Cylindrical Mirror.*

Cylindrical mirrors.

We have already (see p. 382) described the principle of cylindrical mirrors. If we suppose one of these mirrors, AB, fig. 107, to be placed on a table, with the portrait of any person laid before it on the table, the reflected picture of the portrait in the cylindrical mirror will be distorted. If we take an accurate drawing of this distorted picture and lay it before a cylindrical mirror, as shown at MN, where the human form can scarcely be recognised, we shall see in the cylindrical mirror its image reduced to symmetry.

Fig. 107.

2. *On the Camera Obscura.*

Camera obscura.

We have already explained the principle of the camera obscura in treating of the images formed by convex lenses. The instrument is indeed nothing more than a convex lens placed in a suitable box, on the side or bottom of which an image of external objects is formed by the lens.

A convenient portable camera obscura for drawing objects is shown in fig. 108. The external object or landscape is reflected down into the lens AB by an inclined mirror CD. The rays thus falling vertically upon the lens, are refracted to their foci, and form a distinct image of the landscape on the paper placed at EF. On one side of the box there is an opening through which the observer introduces his head and hand, care being taken, by a curtain of black cloth behind him, to exclude all extraneous light. M. Cauchoix of Paris has found that the best form of the lens for a camera is a meniscus, having its convex surface towards the image, and its concave surface towards the object, and their radii of curvature as 5 to 8.

Fig. 108.

3. *On the Magic Lantern.*

Magic lantern.

The magic lantern, an invention of the celebrated Athanasius Kircher, is shewn in fig. 109. It consists merely of a lens AB, which forms on the wall of a dark room a picture of any object placed before it, and at a greater distance than its anterior principal focus. The light of an argand lamp is thrown in a condensed state by the illuminating lens D, upon transparent varnished pictures painted on long sliders. The lens AB forms a large circle of light upon the wall, which, if it is not smooth and white, should be covered with a white smooth cloth, and the images of the coloured figure appear within this circle.

Fig. 109.

A magic lantern is the same as a solar microscope, the

[1] An analysis of this and similar experiments will be found in the *Lond.* and *Edin. Phil. Mag.* Ed. 1832, p. 249.

Optical instruments || Optimates.

sun being used for the source of light in the latter case, and natural objects in place of pictures. The *solar camera microscope* invented by Dr. Goring, and fully described in our article MICROSCOPE, vol. xv. p. 46, and the *oxyhydrogen microscope*, described in the same article, may be considered as the most perfect magic lanterns that have been constructed, there being no difficulty in adapting them to give magnified representations of minute transparent paintings.

4. *On the Phantasmagoric Apparatus.*

Phantasmagoric apparatus.

The apparatus for the *phantasmagoria*, or the raising of spectres, is nothing more than a magic lantern mounted upon wheels, which, in place of throwing its pictures upon an opaque white ground, upon which the spectator looks, throws them upon one side of an imperfectly transparent screen, the spectator viewing them on the other side of the screen. The direct light of a lamp A, fig. 110, and the light reflected from the concave mirror B, is thrown upon the two illuminating lenses C, D, which condense it, and thus strongly illuminate the spectres and figures painted upon sliders at E. These sliders are placed a little before the anterior focus of the magnifying lens F, which forms a highly magnified picture of the figures on the transparent screen at G. When this apparatus is mounted upon a carriage with wheels, as at H, it may be made to approach to, or recede from, the screen G, in consequence of which the figures may be made to contract into dwarfs, disappearing in a point of light, or swell out into giants of enormous magnitude. In order, however, to have the pictures distinct at different distances of the apparatus from the screen, an adjustment is necessary, to make the distance EF increase as the apparatus approaches to G, and diminish as it recedes from it. With this view, the lens F is fixed to a slider, which may be drawn out by the general frame H. When this frame H is drawn away from the screen, the point K is brought lower by means of the rod IK, connected with another rod KN fixed to the frame of the screen at N, where there is a joint or centre of motion. The descent of the point K causes another lever KL to move the horizontal slider (which carries the lens F) in such a manner as to keep the screen always in the focus of F, and consequently the picture upon it always distinct. When the frame H, on the other hand, advances to the screen, the point K rises, and the lens F is again adjusted by the motion of the slider. When the images diminish and appear to vanish, the support of the lens F permits the screen M to fall and intercept part of the light. The screen M may have a triangular opening, so as to uncover the middle only of the lens F. In this adjusting apparatus the rods KN and KL must be equal, and the point I must be twice the focal length of the lens F before the object, L being immediately under the focus of the lens. The object of the screen M is to diminish the illumination of the objects as they get smaller and appear to retire from the spectator, because in the instrument they actually become brighter.

Fig. 110.

When M. Robertson exhibited this remarkable instrument, living persons were often strongly illuminated and introduced into the picture. The effect of life, however, was better given when the shadows of living objects only were introduced.

For farther information on the subject of this article, see ASTRONOMY, vol. iv. p. 101, chap. iv. ACHROMATIC TELESCOPES, BURNING INSTRUMENTS, CAMERA LUCIDA, CHROMATICS, COLOURS, KALEIDOSCOPE, METEOROLOGY, MICROMETER, MICROSCOPE, PHOTOMETER, and TELESCOPE. (N. N. N.)

Optical instruments || Oracle.

OPTIMATES, one of the divisions of the Roman people, and opposed to *populares*. It is not easy to ascertain the characteristic differences of these two parties. Some say the *optimates* were warm supporters of the dignity of the chief magistrate, and promoters of the grandeur of the state, caring not if the inferior members suffered, provided the superior powers were advanced; whereas the *populares* boldly contended for the rights of the people, claimed larger privileges, and laboured to bring matters nearer to an equality. In short, according to this account, they resembled the court and country parties amongst the people of this island. Cicero says that the *optimates* were the best citizens, who wished to deserve the approbation of the better sort; and that the *populares* courted the favour of the populace, not so much considering what was right, as what would please the people and gratify their own thirst of vain-glory and applause.

OPTIO, an officer in the Roman army, who was an assistant or lieutenant to the centurion. The *optio* was so called because in later times he was the choice or option of the centurion; at first, however, he derived his appointment from the tribune or commander of the legion. Sometimes the *optiones* were also called *succenturiones* and *tergiductores;* the latter name having been given them because their post was in the rear of the company. Several authors mention *sub-optiones* or sub-lieutenants. It is proper, however, to add, that *optiones* were not peculiar to the camp, but were also employed in a variety of other offices.

OR, the French word for gold, by which this metal is expressed in heraldry. In engraving it is denoted by small points all over the field or bearing.

ORA, in *Antiquity*, was a term equivalent to ounce; but it has been much debated amongst our antiquaries, whether the ora, the mention of which so often occurs, was a coin, or only money of account. Dr Hickes observes, that the mode of reckoning money by marcs and oras was never known in England until after the settlement of the Danes; and by examining the old nummulary estimates amongst the principal Gothic states upon the Baltic, it appears that the ora and *solidus* were synonymous terms, and that the ora was the eighth part of the marc. From several of the Danish laws, it likewise appears that the Danish ora, derived by corruption from *aurea*, was the same as the Frank *solidus* of twelve pence. As a weight, the ora was regarded as the *uncia* or unit, by which the Danish marc was divided; and in Doomsday-book the ora is used for the ounce, or the twelfth part of the nummulary Saxon pound, and the fifteenth of the commercial. As a coin it was an *aureus*, or the Frank *solidus* of twelve pence; and from the accidental coincidence of the Frank *aureus* with the eighth part of the marc, the Danes probably took occasion to give it the new name of ora. Another ora is mentioned in the rolls of the 27th of Henry III. the value of which was sixteen pence; and this was probably derived from the half mancus of the Saxons, as there were no *aurei* of that period to which these two denominations of money of sixteen and twelve pence could possibly be ascribed. It may be further observed, that the name ora distinguishes the gold coins in several parts of Europe to this day. The Portuguese moidore is nothing else but *moeda d'oro*, from the Latin *moneta de auro;* the French *louis d'or* comes from the same use of the word, and owes its appellation to the ora.

ORACLE, amongst the heathens, was the answer which the gods were supposed to give to those who consulted them upon any affair of importance. It is also used for the god who was thought to give the answer, and for the place where the response was given.

Oracle. The credit of oracles was so great that in all doubts and disputes their determinations were held as sacred and inviolable. Hence vast numbers flocked to them for advice about the management of their affairs; and no business of any consequence was undertaken, scarcely any peace concluded, any war waged, or any new form of government instituted, without the advice and approbation of some oracle. The answers were usually given by the intervention of the priest or priestess of the god who was consulted; and were generally expressed in such dark and unintelligible phrases, as might easily be wrested to prove the truth of the oracle, whatever the event should happen to be. It is not, therefore, to be wondered at, that the priests who delivered them were in the highest credit and esteem; and that they managed this reputation so as greatly to promote their own particular advantage. They accordingly allowed no man to consult the gods before he had offered costly sacrifices and made rich presents to them. Nor was this all. To keep up the veneration for their oracles, and to prevent their being taken unprepared, they admitted persons to consult the gods only at certain stated times; and sometimes they were so cautious, that the greatest personages could obtain no answer at all. Thus Alexander himself was peremptorily denied by the Pythia or priestess of Apollo, till she was by downright force obliged to ascend the tripos, when, being unable to resist any longer, she cried out, "Thou art invincible;" and these words were accepted instead of any further oracle.

When men began to be better instructed by the lights which philosophy had introduced into the world, the false oracles insensibly lost their credit. Chrysippus filled an entire volume with false or doubtful responses. Œnomaus, to be revenged of some oracle which had deceived him, made also a compilation of responses, to show their ridiculous vanity. Eusebius has preserved some fragments of this criticism on oracles by Œnomaus. "I might," says Origen, "have recourse to the authority of Aristotle and the Peripatetics, to make the Pythoness much suspected; I might extract from the writings of Epicurus and his followers an abundance of things to discredit oracles; and I might show that the Greeks themselves made no great account of them."

The reputation of oracles was greatly lessened when they became an artifice of politics. Themistocles, having the design of engaging the Athenians to abandon Athens, and to embark on board of their ships, in order to be in a better condition to resist Xerxes, made the Pythoness deliver an oracle, commanding them to take refuge in wooden walls. Demosthenes said, that the Pythoness "philippized," to signify that she was gained over by Philip's presents.

The cessation of oracles is attested by several profane authors, as Strabo, Juvenal, Lucian, and others. Plutarch accounts for it, by saying that the benefits of the gods are not eternal as themselves are; that the genii who presided over oracles are subject to death; and that the exhalations of the earth had been exhausted. It appears that the last reason had been alleged in the time of Cicero, who ridicules it in his second book on Divination; as if the spirit of prophecy, supposed to be excited by subterraneous effluvia, had evaporated by length of time, as wine or other liquors by being long kept.

Suidas, Nicephorus, and Cedrenus, relate that Augustus, having consulted the oracle of Delphos, could obtain no other answer but this: "The Hebrew child, whom all the gods obey, drives me hence, and sends me back to hell; get out of this temple without speaking one word." Suidas adds, that Augustus dedicated an altar in the capitol, with this inscription, "To the eldest Son of God." But notwithstanding these testimonies, the answer of the oracle of Delphos to Augustus seems very suspicious. Cedrenus cites Eusebius for this oracle, which is not now found in his works; and the peregrination of Augustus into Greece took place eighteen years before the birth of Christ. Oracle.

Suidas and Cedrenus also give an account of an ancient oracle delivered to Thulis, a king of Egypt, which they assure us is well authenticated. The king having consulted the oracle of Serapis, to know if there ever was, or would be, one so great as himself, received this answer: "First God, next the Word, and then the Spirit with them; they are equally eternal, and make but one whose power will never end; but do thou, mortal, get thee hence, and think that the end of the life of man is uncertain."

Van Dale, in his treatise of oracles, does not believe that they ceased at the coming of Christ. He relates several examples of oracles which were consulted until the death of Theodosius the Great; and he quotes the laws of the Emperors Theodosius, Gratian, and Valentinian, against those who consulted oracles, as affording certain proof that the superstition of oracles still subsisted in the time of those emperors. But others conceive that the opinion of those who believe that demons had no share in the oracles, and that the coming of the Messiah made no change in them, as well as the contrary opinion of those who pretend that the incarnation of the Word imposed a general silence on all oracles, should all be equally rejected. They allege that two sorts of oracles ought to be distinguished; the one dictated by the spirits of darkness, who deceived men by their obscure and doubtful answers; the other, the pure artifice and deception of the priests of false divinities. As to the oracles given out by demons, the reign of Satan was destroyed by the coming of the Saviour; truth shut the mouth of lies; but Satan still continued his old craft amongst idolaters. All the devils were not reduced to silence at the same time by the coming of the Messiah; it was only on particular occasions that the truth of Christianity and the virtue of Christians imposed silence on the devils. St Athanasius tells the Pagans that they had themselves been witnesses of the sign of the cross having put the devils to flight, silenced oracles, and dissipated enchantments. This power of silencing oracles, and putting the devils to flight, is also attested by Arnobius, Lactantius, Prudentius, Minutius Felix, and several others, whose testimony affords certain proof that the coming of the Messiah had not imposed a general silence on oracles.

Plutarch relates, that the pilot Thamus heard a voice in the air, crying out, "The great Pan is dead;" upon which Eusebius observes, that the accounts of the death of the demons were very frequent in the reign of Tiberius, when Christ drove out the wicked spirits. Indeed the same judgment may be passed on oracles as on *possessions*. It was on particular occasions, by the divine permission, that the Christians cast out devils, or silenced oracles, in the presence, and even by the confession, of the Pagans themselves; and thus it is that we should understand the passages of St Jerome, Eusebius, Cyril, Theodoret, Prudentius, and other authors, who have said that the coming of Christ imposed silence on the oracles.

As to the second sort of oracles, which were pure artifices and deceptions of the priests of false divinities, and which probably exceeded the number of those which immediately proceeded from demons; they did not cease till idolatry was abolished, though they had lost their credit for a considerable time before the coming of Christ. It was concerning this more common and general sort of oracles, Minutius Felix observed, that they began to discontinue their responses, according as men began to be more enlightened. But, however oracles were decried, impostors always found dupes, and the grossest cheats almost never failed to deceive.

Daniel discovered the imposture of the priests of Bel, who had a private way of getting into the temple to take away the offered meats, and who made the king believe

Oracle. that the idol had consumed them. Mundus, being in love with Paulina, the eldest of the priestesses of Isis, went and told her, that the god Anubis, being passionately fond of her, commanded her to give him a meeting. She was afterwards shut up in a dark room, where her lover Mundus, whom she believed to be the god Anubis, was concealed. This imposture having been discovered, Tiberius ordered those detestable priests and priestesses to be crucified, and with them Idæa, the freed-woman of Mundus, who had conducted the whole intrigue. He also commanded the temple of Isis to be levelled with the ground, and her statue to be thrown into the Tiber; but as to Mundus, he contented himself with sending that person into banishment.

Theophilus, bishop of Alexandria, not only destroyed the temples of the false gods, but discovered the cheats of the priests, by showing that the statues, some of which were of brass, and others of wood, were hollow within, and led into dark passages made in the wall.

Lucian, in discovering the impostures of the false prophet Alexander, says that the oracles were chiefly afraid of the subtilties of the Epicureans and the Christians. The false prophet Alexander sometimes feigned himself seized with a divine fury, and by means of the herb sopewort, which he chewed, frothed at the mouth in so extraordinary a manner that the ignorant people attributed it to the power of the god by whom he was possessed. He had long before prepared a head of a dragon made of linen, which opened and shut its mouth by means of a horse-hair. He went by night to a place where the foundations of a temple were digging; and having found water, either of a spring, or of rain which had settled there, he hid in it a goose egg, in which he had enclosed a little serpent that had just been hatched. The next day, very early in the morning, he came quite naked into the street, having only a scarf about his middle, holding in his hand a scythe, and tossing about his hair like the priests of Cybele; then getting on the top of a high altar, he said that the place was happy to be honoured by the birth of a god. Afterwards, running down to the place where he had hidden the goose egg, and going into the water, he began to sing the praises of Apollo and Æsculapius, and to invite the latter to come and show himself to men. At these words, he dipped a bowl into the water, and took out the mysterious egg, which had a god enclosed in it; and when he had it in his hand, he began to say that he held Æsculapius. Whilst all were eager to have a sight of this fine mystery, he broke the egg, and the little serpent starting out, twisted itself about his fingers.

These examples show clearly that both Christians and Pagans were so far agreed as to treat the greater number of oracles as purely human impostures. That in fact *all* of them were so, will perhaps be concluded by those who give equal credit to demoniacal inspiration and demoniacal possession. The most ancient oracle was that of Dodona; but the most famous was that of Delphi, which performs such a prominent part in Pagan antiquity. Another celebrated one was the oracle of Trophonius, in the neighbourhood of Lebadia, a city of Bœotia. It was held in high estimation, and received its name from Trophonius, brother of Agamedes, who lived in a subterranean dwelling near Lebadia, and pretended to possess the faculty of foretelling future events. He died in his cave, and was deified as an oracular divinity. This oracle owed its reputation to one Saon. Those who repaired to this cave for information were required to offer certain sacrifices, to anoint themselves with oil, and to bathe in a certain river. They were then clothed with a linen robe, took a honeyed cake in their hands, and descended into the subterranean chamber by a narrow passage; and here it was that futurity was unfolded to them, either by visions or by extraordinary sounds. The return from the cave was by the same passage; but the persons consulting the oracle were obliged to walk backwards. They generally came out astonished, melancholy, dejected; and hence the proverb εἰς Τροφωνίου μεμαντευται. The priests, on their return, placed them upon an elevated seat, called the seat of Mnemosyne, where an account was taken of what they had seen and heard. They were then conducted by their companions to the chapel of good Genius, where, by degrees, they recovered their usual composure and cheerfulness. Oracle.

Besides these three principal oracles of Greece, it is proper to take notice of that of Amphiaraus at Oropius, in Attica. It was so called from Amphiaraus, the son of Oicleus, a man deeply skilled in magic, the interpretation of dreams, and the like, who, after his death, was deified, and delivered oracles in a temple erected to his divinity. Those who applied for information were required to purify themselves, offer sacrifice, fast twenty-four hours, abstain from wine two days, and make an offering of a ram to Amphiaraus; they were then to sleep on the skin of the animal, and to see their destiny in a dream. Near the temple was the fountain of Amphiaraus, which was deemed sacred, the waters of it being forbidden to be used for ordinary purposes.

At Delos there was also an oracle of the Delian Apollo; in Milesia there was that of the Branchidæ; and there were others of less note, which do not require particular description, such as that of the camps at Lacedæmon, that of Nabarcha, that of Chrysopolis, that of Claros in Ionia, that of Mallos, that of Patarea, that of Pella, that of Phasellides, that of Sinope, that of Orpheus' head, and a few more, which it is unnecessary to mention.

Although the Romans upon many occasions consulted the Grecian oracles, and had but few in their own country, yet we must not omit mentioning the oracles which were delivered by the Sibyl of Cumæ, and enjoyed great celebrity. They have been frequently alluded to by Virgil.

We have hitherto only considered the oracles of false gods, of which there was a far greater number than our limits permit us to enumerate, and before either Greeks or Romans had risen to any distinction. Oracle is in sacred history sometimes used for the mercy-seat, or the cover of the ark of the covenant; and by others it is taken for the sanctuary, or the most holy place, in which the ark was deposited.

Amongst the Jews may be distinguished several kinds of real oracles. They had first oracles which were delivered *viva voce*, as when God spake to Moses face to face, as one friend speaks to another;[1] secondly, prophetical dreams sent by God, as the dreams which God sent to Joseph, and which foretold his future greatness;[2] thirdly, visions, as when a prophet in an ecstasy, being neither properly asleep nor awake, had supernatural revelations;[3] fourthly, the oracle of Urim and Thummim, which was accompanied with the ephod or the pectoral worn by the high priest, and which God had endued with the gift of foretelling things to come.[4] This manner of inquiring of the Lord was often made use of, from Joshua's time till the erection of the temple at Jerusalem. Fifthly, after the building of the temple, they generally consulted the prophets, who were numerous in the kingdom of Judah and Israel. From Haggai, Zechariah, and Malachi, who are the last of the prophets any of whose writings remain, the Jews pretend that God gave them what they call *Bathcol*, or the daughter of the voice, which was a supernatural Oracle.

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[1] Numb. xii. 8. [2] Gen. xxxvii. 5, 6. [3] Gen. xv. 1; xlvi. 2. [4] Numb. xii. 6; Joel, ii. 28.

Oracle.

manifestation of his will, and was performed either by a strong inspiration or internal voice, or else by a sensible and external voice, which was heard by a number of persons sufficient to bear testimony to the fact. For example, such was the voice that was heard at the baptism of Jesus Christ, saying, "This is my beloved Son, in whom I am well pleased; hear ye him."[1]

The Scripture likewise affords us examples of profane oracles. Balaam, at the instigation of his own avarice, and fearing to lose the recompense which had been promised him by Balak, king of the Moabites, suggested to this prince the diabolical expedient of making the Israelites fall into idolatry and fornication;[2] by which he assured him of a certain victory, or at least of considerable advantage against the people of God.

Micaiah the son of Imlah,[3] a prophet of the Lord, says that he saw the Almighty sitting upon his throne, and all the host of heaven round about him; and the Lord said, who shall tempt Ahab king of Israel, that he may go to war with Ramoth-gilead, and fall in the battle? One answered after one manner, and another after another. At the same time an evil spirit presented himself before the Lord, and said, I will seduce him. And the Lord asked him, how? To this Satan answered, I will go and be a lying spirit in the mouth of his prophets. And the Lord said, Go, and thou shalt prevail. This dialogue clearly proves these two things: first, that the devil could do nothing by his own power; and, secondly, that, with the permission of God, he could inspire the false prophets, sorcerers, and magicians, and thus make them deliver false oracles.

Respecting the cessation of profane oracles, there have been a variety of opinions, some of which we have already noticed. It has been generally held, indeed, that oracles ceased at the birth of Jesus Christ. Yet some have endeavoured to maintain the contrary, by showing that they were in existence in the days of Julian, commonly called the Apostate, and that this emperor himself consulted them; that history makes mention of several laws published by the Christian emperors Theodosius, Gratian, and Valentinian, to punish persons who interrogated them, even in their days; and that the Epicureans were the first who made a jest of this superstition, and exposed to the people the roguery of the priests. As we suspect most of the facts here asserted should be understood in a qualified sense, we shall endeavour to discuss this point of controversy in as few words as possible, although it is undoubtedly a matter of some consequence.

1*st*, The question, properly stated, is not, whether oracles became extinct immediately upon the birth of Christ, or from the very moment when he was born; but, whether they fell gradually into disesteem and ceased, as Christ and his gospel became known to mankind. And that they did so, is most certain from the concurrent testimonies of the fathers, which none can attempt to invalidate, without being prepared to give up the most respectable traditions and relations of every kind.

2*dly*, But did not Julian the Apostate actually consult these oracles? We answer in the negative. He had indeed recourse to magical operations, but it was because oracles had already ceased; for he bewailed the loss of them, and assigned for their cessation pitiful reasons, which St Cyril has vigorously refuted, adding, that Julian "never could have offered such, but from an unwillingness to acknowledge that, when the world had received the light of Christ, the dominion of the devil was at an end."

3*dly*, The Christian emperors do indeed condemn the superstition and idolatry of those who were still disposed to consult oracles; but the edicts of these princes do not prove that oracles actually existed in their times, any more than that they had ceased in consequence of their laws. It is certain that they were for the most part extinct before the conversion of Constantine.

Oræa ‖ Oran.

4*thly*, Some Epicureans might make a jest of this superstition; but the Epicurean philosopher Celsus, in the second century, was disposed to cry up the excellency of several oracles, as appears at large from Origen's seventh book against him.

ORÆA, certain solemn sacrifices of fruits, which were offered in the four seasons of the year, in order to obtain mild and temperate weather. They were offered to the goddesses who presided over the seasons, attended upon the sun, and received divine worship at Athens.

ORAL, something delivered by word of mouth, without being committed to writing. In this sense we say oral law, oral tradition, oral communication, and the like.

ORAN, WARRAN, AURAN, or GUHARAN, a famous maritime city of Algiers, and the most westerly in the regency. It is built on the declivity and along the foot of a high mountain, which overlooks it from the north and north-west; and on this ridge are planted two castles, commanding the city on the one side and the port on the other. To the south and south-east there are two other castles, erected upon the same level with the lower part of the city, but separated from it by a deep winding valley, which serves as a natural trench on the south side. A rivulet flows through it, and passing afterwards under the walls of the city, affords a copious supply of water. At every opening of this valley a pleasing and varied prospect presents itself, of rocky precipices, orange plantations, and rills of water winding down the heights. Near the head of the rivulet just mentioned there is a fifth castle, which not only guards the *mattamores* dug under its walls, but serves as an important defence to the city. Yet strongly fortified as Oran is, both by nature and art, it has been repeatedly taken by the Spaniards, between whom and the Moors it was for centuries a subject of contention. It was taken by the former in the year 1509, but was recovered by the Moors in 1708. In the year 1732 the Spaniards retook it by surprise; the Bey, otherwise a valiant soldier, having been panic-struck on the first landing of the enemy, and, without shutting the gates, abandoned the city to their mercy. Oran was afterwards restored, and, along with other parts of Algiers, has recently fallen under the dominion of France. During the time that the Spaniards retained possession of Oran, they erected several beautiful churches, and other edifices, in the style of the Roman architecture, though of less strength and solidity. They have further imitated the Romans in carving upon the friezes and other parts several inscriptions in large characters, and in their own language. Shaw describes Oran as a fortified city, about a mile in circumference. The port called Mer-el-Quiver, corrupted from Mers-el-Kibeer, and answering to the ancient Portus Magnus, is formed by a neck of land, which runs out almost a furlong into the bay, and thereby secures it against the north and north-west winds. It is defended by a castle more remarkable for spaciousness and extent than for strength or beauty, though a part of it has been skilfully hewn out of the native rock. Oran has much declined of late years, as the occupation of the place by the French has induced the Arab population to leave it, although the former repaired some of the edifices, and converted an old mosque into an hospital. The inhabitants are estimated at about 4000. In the year 1790 this city was destroyed by an earthquake, and six thousand of its inhabitants were buried under the

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[1] Matth. iii. 17. [2] Numbers, xxiv. 14; xxxi. 16. [3] 1 Kings, xxii. 19, &c.

Orange ‖ Orange, Sea.

ruins. Oran is situated in 35. 50. north, and longitude 0. 18. west.

ORANGE, an arrondissement of the department of the Vaucluse, in France, extending over 361 square miles. It comprehends seven cantons, divided into forty-eight communes, and contains 67,443 inhabitants. The capital, a city of the same name, is the seat of a bishop, and of some courts of law. It stands on a fruitful plain, watered by the river Meyne. It has large lofty houses, with narrow and crooked streets, a cathedral, a Protestant church, two hospitals, 1540 houses, and 8874 inhabitants, who make cotton, woollen, and silk goods, besides oil, wine, brandy, madder, and paper. It is in latitude 49. 4. N., and longitude 8. 8. east. It is remarkable as the district whence the house of Nassau derived its title as prince, which it has retained without the territory. The vicinity of the city exhibits many curious remains of Roman antiquity, especially a triumphal gate of three arches, half a mile from it, on a theatre, the walls of which are 108 feet in height. A part of this building has of late years been converted into a prison.

ORANGE River, a large river of Southern Africa, which derives its origin from the waters of the Snowy Mountains, in the district of Graaf-Reynet, nearly at the north-eastern extremity of the colony of the Cape of Good Hope. It is formed chiefly by two rivers, the Ky Gariep or Yellow River, and the Nu Gariep or Black River, which unite their waters in latitude 29. 4., upwards of five hundred miles due east from their mouth. The latter branch, flowing from the south-east, is called, higher up, the Cradock River, and receives the Sea-Cow River and some other streams from the Sneuwbergen. The Muddy or Alexander River, flowing also from the south-east, falls into the Yellow River above its confluence with the Nu Gariep. The former river, the Ky Gariep, comes from the north-east, and is formed by the union of the Vaal River with the Hart stream or Malalareen. After the junction of these two streams, the Orange River flows at first in a north-westerly course, but afterwards bends to almost due west, which bearing it maintains until it falls into the Atlantic in latitude 28. 30. north. In the eastern part of its course it forms the limit between the territory of the Hottentots and that of the Boshuanas; the country on the south presenting an entirely different character of animal and vegetable life from that on the north. In its westerly course this river winds its way through a desert of a clayey or swampy character; the sandstone rocks rising in perpendicular walls, which are often prolonged to a vast extent. The country retains the same aspect for a considerable space on both sides of the river; and the heat is here very great and oppressive. The course of the Orange River, including its windings, must considerably exceed one thousand miles.

Orange, Sea, in *Natural History*, a name given by Count Marsigli to a very remarkable species of marine substance, which he denominates a plant. It is tough and firm in its structure, and in many things resembles the common fucus; but instead of growing in the branched form which the generality of these substances assume, it is round and hollow, and in every respect resembles the shape of an orange. It has, by way of root, some exceedingly fine filaments, which fasten themselves to the rocks, or to shells, stones, or any thing else that comes in the way. From these there grows no pedicle; but the body of the orange, as it is called, is fastened by them to the rock, or other solid substance. The orange itself is usually about three or four inches in diameter; and whilst in the sea it is full of water, which it retains even when taken up. In this state it frequently weighs a pound and a half; but when the water is let out, and it is dried, it becomes a mere membrane, weighing scarcely any thing. It is best preserved by stuffing it with cotton as soon as the water is let out of it, and then hanging it up to dry. Its surface is irregular and rough, and its colour is a dusky green on the outside, and a clearer but somewhat bluish green within; and its thickness is about an eighth part of an inch. When viewed by the microscope, it is observed to be all over covered with small glandules, or rather composed of them; for they stand so thick one by another, as to leave no space between, and seem to constitute the whole substance; so that it appears very like the rough shagreen skin used to cover toys. These are indeed so many hollow ducts, through which the sea-water finds a passage into the globe formed by this skin, and by this means it is kept always full and distended. On cutting it with a pair of scissors, the water immediately runs out, and the skins collapse; but there is something extremely remarkable in this, for the whole substance, near the wounded place, is in motion, and seems as if alive, and sensible of the wound. The glandules are found full of water, resembling small transparent bottles; and what goes to the structure of the plant besides these, is an assemblage of a vast number of filaments, all of which are likewise hollow, being filled with a clear and transparent fluid.

Oration ‖ Orchestra.

ORATION, in *Rhetoric*, a speech or harangue, composed according to the rules of oratory, but spoken in public.

ORATOR, amongst the Romans, differed from a *patronus*. The latter was allowed only to plead causes on behalf of his clients; whereas the former might quit the forum, and ascend the rostra or tribunal, to harangue the senate or the people. The orators had rarely a profound knowledge of the law; but they were eloquent, and their style was generally correct and concise. They were employed in causes of importance, instead of the common patrons. Orators, in the violence of elocution, used the utmost animation of gesture, and even walked backwards and forwards with great heat and emotion. This it was which gave occasion to a witticism of Flavius Virginius, who asked one of these walking orators, *Quot millia passuum declamâsset?* "How many *miles* he had declaimed?" Similar to the Roman orators were the Grecian *rhetores*.

ORATORIO, in *Music*, a kind of sacred drama, in which the poetry is derived from some scriptural subject, and is set to music in recitatives, airs, duetts, trios, quartetts, &c. and choruses, accompanied by an orchestra, sometimes an organ, and introduced by an instrumental overture. The origin of the oratorio is not clearly established. Amongst the most remarkable oratorios of modern times is Haydn's "Creation."

ORATORY, the art of speaking well upon any subject, so as to persuade or convince. See Rhetoric.

Oratory, amongst the Roman Catholics, means a closet or small apartment near a bed-chamber, furnished with an altar and crucifix, for private devotions.

ORBE, a small city of Switzerland, in the canton of Vaud, on the river of the same name, across which there is a stone bridge. It contains 280 houses, with 1400 inhabitants. Anciently it was one of the largest of the cities in the country, and in the time of the Romans was, under the name of Urbigenum, the capital of Helvetia. In the middle ages the kings of the Franconian race had their palace here, and gave their splendid festivals; but in the Burgundian wars it suffered greatly, and declined so much as to become subject to the cantons of Berne and Friburg. It now contains some large houses. The inhabitants chiefly depend on agriculture, but have some trade with Geneva and Yverdun.

ORCHARD, a department in gardening, allotted entirely to the growth of standard fruit-trees, for furnishing a large supply of the most useful kinds of fruit. See Horticulture.

ORCHESTRA, in *Music*. See the article Music.

Orchestra ‖ Orcus.

ORCHESTRA, in the Grecian theatres, was that part of the *proscenium* or stage where the chorus used to dance. In the middle of it was placed the Λογειον or pulpit. The orchestra was semicircular, and surrounded with seats. In the Roman theatres it formed no part of the scene, but answered pretty nearly to the pit in our playhouses, being occupied with seats for senators, magistrates, vestals, and other persons of distinction. The actors never went down into the orchestra.

ORCHESTRINO, a modern musical instrument, so called by its inventor Poulleau. It was shaped like a piano-forte, had similar finger-keys, and its sounds were produced by the friction of a circular bow upon the strings. It imitated the tones of the violin, the viola, the violoncello, the viol d'amour, the double-bass, &c. The construction of the bow (of hair, &c.) is said to have been very curious and ingenious.

ORCHESTRION, a musical instrument invented by the Abbé Vogler about 1789. It was a kind of portable organ, about nine feet in height, breadth, and depth. Its power was that of an organ of sixteen feet pipe, and it had a mechanism to swell or to diminish all the sounds within its compass. Another instrument of the same name, invented in 1796, by Kunz, a Bohemian, consisted of a piano-forte, combined with some organ-stops.

ORCHIA Lex, instituted by Orchius the tribune, in the year of Rome 566. Its intention was to limit the number of guests who were to be admitted at an entertainment; and it is also provided that, during supper, which was the principal meal amongst the Romans, the doors of every house should be left open.

ORCHILLA, or Horchilla, a small cluster of islands in the West Indies, situated not far from the coast of South America, in latitude 12. north, and longitude 65. 20. west. The largest island, which bears the form of a crescent, is very hilly on the east and west capes, and here trees and verdure abound; but the other parts are low, and the soil, from its flatness, is barren, and productive of very few plants. There is little fresh water, no animals except goats and lizards, nor does it appear to contain any permanent population. On the south-west side the shore is nearly as perpendicular as a wall, and the water being very deep, vessels can approach close to it without danger. Navigation is extremely difficult amongst the Orchillas; for not only are the islands separated from each other by very narrow channels, but there are a number of currents, variable, violent, and dangerous.

ORCHON, a river of Chinese Tartary, which has its rise on the confines on the great desert of Shamo, and falls into the Selingha. Long. 106. 14. E. Lat. 50. N.

ORCUS, the god of the infernal regions, was the same with Pluto, and so called from the Greek word ὄρχος, signifying a tomb or sepulchre; or from ὅρκος, an oath sworn by the river Styx. The ancients gave this name to all the divinities of the infernal regions, even to Cerberus. There was a river of the same name in Thessaly, which took its rise in the marshes of the Styx, and the waters of which were so thick that they floated like oil upon the surface of the river Peneus, into which they discharged themselves. This probably suggested to the poets the idea of the infernal abodes, which they denominated Orcus. Orcus has been confounded with Charon. He had a temple at Rome. Ordeal.

ORDEAL, an ancient form of trial. It consisted in an appeal to the immediate interposition of divine power, being particularly distinguished by the appellation of *judicium Dei;* and was sometimes called *purgatio vulgaris*, to distinguish it from the canonical purgation, which was by the oath of the party. Two kinds of this trial were more common than the rest, at least in Europe; viz. fire-ordeal and water-ordeal. The former was confined to persons of high rank, the latter to the common people. Both these might be performed by deputy; but the principal was bound to answer for the success of the trial, the deputy only venturing some corporal pain, for hire, or perhaps for friendship.

That the purgation by ordeal, of some kind or other, is very ancient, admits not of a doubt; and that it was universal in the times of superstitious ignorance, seems to be equally certain. It appears even to have been known to the ancient Greeks; for, in the *Antigone* of Sophocles, a person suspected by Creon of a misdemeanour, declares himself ready "to handle hot iron and to walk over fire," in order to manifest his innocence, which, the scholiast tells us, was then an usual mode of purgation. And Grotius gives many instances of water-ordeal in Bithynia, Sardinia, and other places. It seems, however, to have been carried to a greater height amongst the Hindus than ever it had been in any nation or amongst any people, however rude or barbarous; for in a paper in the Asiatic Researches, communicated by Mr Hastings, we find that the trial by ordeal amongst that people is conducted in nine different ways: firstly, by the balance; secondly, by fire; thirdly, by water; fourthly, by poison; fifthly, by the *cosha*, or the water in which an idol has been washed; sixthly, by rice; seventhly, by boiling oil; eighthly, by red-hot iron; and ninthly, by images.

1 Ordeal by the balance is thus performed. The beam having been previously adjusted, the cord fixed, and both scales made perfectly equiponderant, the person accused and a pundit fast a whole day; then, after the accused has been bathed in sacred water, the *homa* or oblation presented to fire, and the deities worshipped, he is carefully weighed; and when he is taken out of the scale, the pundits prostrate themselves before it, pronounce a certain *mentra* or incantation, agreeably to the Shastras, and, having written the substance of the accusation upon a piece of paper, bind it on his head. Six minutes afterwards they place him again in the scale, and if he weigh more than before, he is held guilty; if less, innocent; if exactly the same, he must be weighed a third time, when, as it is written in the *Mitacshera*, there will certainly be a difference in his weight. Should the balance, though well fixed, break down, this would be considered as a proof of his guilt.

2. For the fire-ordeal, an excavation, nine hands in length, two spans in breadth, and one span in depth, is made in the ground, and filled with a fire of pippal-wood. Into this the person accused must walk barefooted; and, if his foot be unhurt, they hold him blameless; but if it be burned, he is held guilty.[1]

3. Water-ordeal is performed by causing the person

[1] In Europe, fire-ordeal was performed either by taking up in the hand, unhurt, a piece of red-hot iron, of one, two, or three pounds weight; or else by walking, barefooted and blindfold, over nine red-hot ploughshares, laid lengthwise at unequal distances; and if the party escaped unhurt, he was adjudged innocent; but if it happened otherwise, as without collusion it usually did, he was then condemned as guilty. However, by this latter method, Queen Emma, the mother of Edward the Confessor, is mentioned to have cleared her character, when suspected of familiarity with Alwyn, bishop of Winchester. The first account which we have of Christians appealing to the fire-ordeal, as a proof of their innocence, is that of Simplicius, bishop of Autun, who lived in the fourth century. This prelate, as the story is related, before his promotion to the episcopal order, had married a wife, who loved him tenderly, and who, unwilling to quit him after his advancement, continued to sleep in the same chamber with him. The sanctity of Simplicius suffered, at least in the voice of fame, by the constancy of his wife's affection; and it was rumoured about that the holy man, though a bishop, persisted, in opposition to the ecclesiastical canons, to taste the sweets of matrimony; upon which his wife, in the presence of a great concourse of people, took up a considerable quantity of burning coals, which she held in her clothes, and applied to her breasts, without the least hurt to her person or her garments, as the legend says; and her example being followed by her husband with similar success, the credulous multitude admired the miracle, and proclaimed the innocence of the loving pair. A similar trick was played by St Brice, in the fifth century. (Mosheim, *Ecclesiast. Hist.* vol. ii.)

Ordeal.

accused to stand in a depth of water, either flowing or stagnant, sufficient to reach his navel; but care should be taken that no ravenous animal be in it, and that it be not moved by much air. A Brahmin is then directed to go into the water, holding a staff in his hand; and a soldier shoots three arrows upon dry ground from a bow of cane. A man is next despatched to bring the arrow which has been shot farthest; and, after he has taken it up, another is ordered to run from the edge of the water; at which instant the person accused is told to grasp the foot or the staff of the Brahmin, who stands near him in the water, and immediately to dive into it. He must remain under water till the two men who went to fetch the arrows have returned; for, if he raise his head or body above the surface before the arrows are brought back, his guilt is considered as fully proved. In the villages near Benares, it is the practice for the person who is to be tried by this kind of ordeal to stand in water up to his navel, and then, holding the foot of a Brahmin, to dive under it as long as a man can walk fifty paces very gently; if, before the man has walked thus far, the accused rise above the water, he is condemned; but if not, he is acquitted.

4. There are two sorts of trial by poison. Firstly, the punadits having performed their homa, and the person accused his ablution, two *rettis* and a half, or seven barley-corns of *vishanaga*, a poisonous root, or of *sauc'hya*, that is, white arsenic, are mixed in eight *mashas*, or sixty-four *rettis*, of clarified butter, which the accused must eat from the hand of a Brahmin. If the poison produce no visible effect, he is absolved; but if otherwise, he is condemned. Secondly, the hooded snake, called *nagga*, is thrown into a deep earthen pot, into which is dropped a ring, a seal, or a coin. This the person accused is ordered to take out with his hand; and, if the serpent bite him, he is pronounced guilty; but if not, he is declared innocent.

5. Trial by the cosha is as follows. The accused is made to drink three draughts of the water in which the images of the sun, of Devi, and other deities, have been washed for that purpose; and if, within fourteen days, he has any sickness or indisposition, his crime is considered as proved.

6. When several persons are suspected of theft, some dry rice is weighed with the sacred stone called *salgram*, or certain *slocas* are read over it; after which the suspected persons are severally ordered to chew a quantity of it. As soon as they have chewed it, they are to throw on it some leaves of *pippal*, or, if none be at hand, some *b'hurja patra*, or bark of a tree from Nepaul or Cashmere. The man from whose mouth the rice comes dry or stained with blood is held guilty; the rest are acquitted.

7. The ordeal by hot oil is exceedingly simple. When it is heated sufficiently, the accused thrusts his hand into it; and, if he be not burned, he is held innocent.

8. In the same manner they make an iron ball, or the head of a lance, red hot, and place it in the hands of the person accused, who, if it burn him not, is judged guiltless.

9. To perform the ordeal by *dharmach*, which is the name of the *sloca* appropriated to this mode of trial, either an image, named *dharma*, or the genius of justice, is made of silver, and another, called *adharma*, of clay or iron, both of which are thrown into a large earthen jar; and the accused having thrust his hand into it, is acquitted if he bring out the silver image, but condemned if he draw forth the iron. Or, one figure of a deity is painted on white cloth, and another on black; the first of which they name *dharma*, and the second *adharma*. These are severally rolled up in cow-dung, and thrown into a large jar, without having ever been shown to the accused, who must put his hand into the jar, and is acquitted or convicted according as he draws out the figure on white or on black cloth.

The superstitious weakness of mankind, when left to themselves, is astonishing. There is indeed nothing so absurd that they may not be made most firmly to believe, nothing so impious that they will not do. Nor can a more notorious instance of the truth of this assertion be possibly given than that of the trial by ordeal. The gross absurdity as well as impiety of pronouncing a man guilty unless he was cleared by a miracle, and of expecting that all the powers of nature should be suspended by an immediate interposition of Providence to save the innocent, when it was even presumptuously required, is self-evident. Yet the origin of this mode of trial may be traced to necessity as well as to superstition. At the time in which it originated in England, as well as in other countries of Europe, it was no easy matter for an innocent person, when accused of guilt, to get himself cleared by the then established mode of trial. It was therefore natural for superstition to fly to Heaven for those testimonies of innocence which the absurdity of human laws often prevented men from obtaining in the ordinary course of affairs. In this way, doubtless, did the trial by ordeal commence; and being thus begun by necessitous superstition, it was fostered by impious priestcraft and unjust power. During all the processes there was great room for collusion and deceit, and there can be no question but it was often practised; it could not, therefore, on any account, or in any case, be a sign of innocence or of guilt.

Ordeal.

Besides the particular methods of trial which we have already mentioned, there were some few more common in European countries; as the judicial combat, the ordeal of the cross, and the ordeal of the corsned.

The judicial combat was well suited to the genius and spirit of fierce and warlike nations, and, as we might reasonably expect, formed one of the most ancient and universal modes of trial. We know that it was exceedingly common in Germany in very remote ages. It was also used in some countries on the Continent at a pretty early period; but it is not mentioned in any of the Anglo-Saxon laws, and it does not appear to have been much used in England until after the Conquest. It was so much the custom in the middle ages of Christianity to respect the cross even to superstition, that it would indeed have been wonderful if the same ignorant bigotry had not converted it into an ordeal; and accordingly we find it used for this purpose in so many different ways as almost to preclude description. In criminal trials, the judgment of the cross was commonly conducted in this manner. When the prisoner had declared his innocence upon oath, and appealed to the judgment of the cross, two sticks were prepared exactly like one another; the figure of the cross was cut on one of these sticks, and nothing on the other; each of them was then wrapped up in a quantity of fine white wool, and laid on the altar, or on the relics of the saints; after which a solemn prayer was offered up to God, that he would be pleased to discover, by evident signs, whether the prisoner was innocent or guilty. These solemnities being finished, a priest approached the altar, and took up one of the sticks, which was uncovered with much anxiety. If it was the stick marked with the cross, the prisoner was pronounced innocent; but if it was the other, he was declared guilty. When the judgment of the cross was appealed to in civil causes, the trial was usually conducted in this manner. The judges, parties, and all concerned, being assembled in a church, each of the parties chose a priest, the youngest and stoutest whom he could find, to be his representative in the trial. These representatives were then placed one on each side of some famous crucifix; and, at a signal given, they both at once stretched their arms at full length, so as to form a cross with their body. In this painful posture they continued to stand whilst divine service was performing; and the party whose representative dropped his arms first lost his cause.

The corsned, or the consecrated bread and cheese, was

Ordeal. the ordeal to which the clergy commonly appealed when they were accused of any crimes; and in this they acted a very prudent part, as it was attended with no danger or inconvenience. This ordeal was performed in this manner. A piece of barley bread and a piece of cheese were laid upon the altar, over which a priest pronounced certain conjurations, and prayed with great fervency, that if the person accused was guilty, God would send his angel Gabriel to stop his throat, that he might not be able to swallow that bread and cheese. These prayers being ended, the culprit approached the altar, took up the bread and cheese, and began to eat it. If he swallowed freely, he was declared innocent; but if it stuck in his throat, and he could not swallow, which we may presume seldom or never happened, he was pronounced guilty.

Besides these, there were a variety of other ordeals practised in Christian countries, many of which retain the same names which were used amongst Pagans, and differ only as to the mode in which they were performed. In all nations of Christians where these trials were used, we find the clergy engaged in them. Indeed, in England, as late as the time of King John, we find grants to the bishops and clergy to use the *judicium ferri, aquæ, et ignis;* and, both in England and Sweden, the clergy presided at this trial, and it was only performed in the churches, or in other consecrated ground. "Non defuit illis operæ et laboris pretium," says Stiernhook; "semper enim ab ejusmodi judicio aliquid lucri sacerdotibus obveniebat." But, to give the canon law its due praise, we find it at a very early period declaring against trial by ordeal, or *vulgaris purgatio*, as being the work of the devil, "cum sit contra præceptum Domini, *Non tentabis Dominum Deum tuum.*" Upon this authority, though the canons themselves were of no validity in England, it was thought proper (as had been done in Denmark above a century before) to disuse and abolish this trial entirely in our courts of justice, by an act of parliament 3 Henry III. according to Sir Edward Coke, or rather by an order of the king in council.

It may still perhaps be a postulate with some in what manner the effects of these trials were evaded, and how it was possible to appear to do that which we know could not be really done without material injury to the persons concerned. On this subject Dr Henry observes, in reference to the ordeals in ancient Britain, that, if we suppose few or none escaped conviction who exposed themselves to those fiery trials, we shall be very much mistaken. "For the histories of those times contain innumerable examples of persons plunging their naked arms into boiling water, handling red-hot balls of iron, and walking upon burning ploughshares, without receiving the least injury. Many learned men have been much puzzled to account for this, and disposed to think that Providence graciously interposed, in a miraculous manner, for the preservation of injured innocence. But if we examine every circumstance of those fiery ordeals with due attention, we shall see sufficient reason to suspect that the whole was a gross imposition on the credulity of mankind. The accused person was committed wholly to the priest who was to perform the ceremony, three days before the trial, in which he had time enough to bargain with him for his deliverance, and give him instructions how to act his part. On the day of trial, no person was permitted to enter the church but the priest and the accused till after the iron was heated, when twelve friends of the accuser, and twelve of the accused, and no more, were admitted, and ranged along the wall on each side of the church, at a respectful distance. After the iron was taken out of the fire, several prayers were said; the accused drank a cup of holy water, and sprinkled his hand with it, which might take a considerable time if the priest was indulgent. The space of nine feet was measured by the accused himself with his own feet, and he would probably give but scanty measure. He was obliged only to touch one of the marks with the toe of his right foot, and allowed to stretch the other foot as far towards the other mark as he could, so that the conveyance was almost instantaneous. His hand was not immediately examined, but wrapped in a cloth prepared for that purpose three days. May we not, then, from all these precautions, suspect that those priests were in possession of some secret that secured the hand from the impressions of such a momentary touch of hot iron, or removed all appearance of these impressions in three days; and that they made use of this secret whenever they saw reason? What greatly strengthens these suspicions is, that we meet with no example of any champion of the church who suffered the least injury from the touch of hot iron in this ordeal; but when any one was so fool-hardy as to appeal to it, or to that of hot water, with a view to deprive the church of any of her possessions, he never failed to burn his fingers, and lose his cause." Ordeal.

To this we may add what the learned Beckmann[1] has stated concerning the imposition which was probably practised in the ordeal by fire. "I am not acquainted with every thing that concerns the trial by ordeal, when persons accused were obliged to prove their innocence by holding in their hands red-hot iron; but I am almost convinced that this was also a juggling trick of the popes, which they employed as might best suit their views. It is well known that this mode of exculpation was allowed only to weak persons, who were unfit to wield arms, and particularly to monks and ecclesiastics, to whom, for the sake of their security, that by single combat was forbidden. The trial itself took place in the church, entirely under the inspection of the clergy; mass was celebrated at the same time; the defendant and the iron were consecrated, by being sprinkled with holy water; the clergy made the iron hot themselves; and they used all these preparatives, as jugglers do many motions, only to divert the attention of the spectators. It was necessary that the accused person should remain at least three days and three nights under their immediate care, and continue as long after. They covered his hands both before and after the proof, sealed and unsealed the covering; the former, as they pretended, to prevent the hands from being prepared any how by art; the latter, to see if they were burned.

"Some artificial preparation was therefore known, else no precautions would have been necessary. It is highly probable, that during the first three days the preventive was applied to those persons whom they wished to appear innocent; and that the three days after the trial were requisite to let the hands resume their natural state. The sacred sealing secured them from the examination of presumptuous unbelievers; for, to determine whether the hands were burned, the last three days were certainly not wanted. When the ordeal was abolished, and this art rendered useless, the clergy no longer kept it a secret. In the thirteenth century, an account of it was published by Albertus Magnus, a Dominican monk.[2] If his receipt be

[1] Vol. iii. 297.

[2] In his work *De Mirabilibus Mundi*, at the end of his book *De Secretis Mulierum*, Amsterdam, 1702, 12mo, p. 100. "Experimentum mirabile quod facit hominem ire in ignem sine læsione, vel portare ignem vel ferrum ignitum sine læsione in manu. Recipe succum bismalvæ, et albumen ovi, et semen psylli et calcem, et pulveriza, et confice cum illo albumine ovi succum raphani; commisce; ex hac confectione illineas corpus tuum vel manum, et dimitte siccari, et postea iterum illineas, et post hoc poteris audacter sustinere ignem sine nocumento."

Order. genuine, it seems to have consisted rather in covering the hands with a kind of paste than in hardening them. The sap of the *althæa* (marshmallow), the slimy seeds of the flea-bane, which is still used for stiffening by the hat-makers and silk-weavers, together with the white of an egg, were employed to make the paste adhere. And by these means the hands were as safe as if they had been secured by gloves.

"The use of this juggling trick is very old, and may be traced back to a Pagan origin. In the *Antigone* of Sophocles, the guards placed over the body of Polynices, which had been buried contrary to the orders of Creon, offered, in order to prove their innocence, to submit to any trial. We will, said they, take up red-hot iron in our hands, or walk through fire."

ORDER, in *Architecture*, is a system of the several members, ornaments, and proportions of columns and pilasters; or a regular arrangement of the projecting parts of a building, especially the column, so as to form one beautiful whole. See ARCHITECTURE.

ORDER is also used to signify a division or class of any thing. Thus the tribe of animals called *birds* is subdivided into orders.

ORDER, in *Rhetoric*, is the placing of each word and member of a sentence in such a manner as will most contribute to the force, beauty, or evidence of the whole; according to the genius and custom of different languages. With regard to order, we may observe in general, that, in English, the nearer we keep to the natural or grammatical order, so much the better; but in Latin we are to follow the use of the best writers, a joint regard being always had to the judgment of the ear, and the perspicuity of the sense, in both languages.

ORDER is also used to signify a class or division of the members of a state, with regard to assemblies, precedence, levees, and other circumstances.

ORDERS, by way of eminence, or *Holy* ORDERS, denote a character peculiar to ecclesiastics, by which they are set apart for the holy ministry.

In no reformed church are there more than three orders, namely, bishops, priests, and deacons. In the Roman Catholic church there are seven, exclusive of the episcopate, all of which the council of Trent enjoins to be received and believed, on pain of anathema. They are distinguished into petty, or secular orders; and major, or sacred orders.

ORDERS, the petty, or minor, are four; those of doorkeeper, exorcist, reader, and acolyte. Persons in petty orders may marry without any dispensation. In effect, the petty orders are looked on as little other than formalities, and as degrees necessary to arrive at the higher orders. The Greeks disavow these petty orders, and pass immediately to the subdeaconate; and the reformed churches to the deaconate. Their rise Fleury dates in the time of the Emperor Justinian. There is no call nor benefice required for the four petty orders; and even a bastard may enjoy them without any dispensation, nor does a second marriage disqualify.

ORDERS, sacred, or major, are, as has already been observed, three, viz. those of deacon, priest, and bishop. The council of Trent, reviving the ancient discipline, forbids any person being admitted to the major orders, unless he be in peaceable possession of a benefice sufficient for a decent subsistence, and allows no ordinations on patrimonies or pensions, except where the bishop judges it for the service of the church. A person is said to be promoted to orders *per saltum*, when he has not before passed the inferior orders. The council of Constantinople forbids any bishop being ordained without passing all the degrees; yet ecclesiastical history furnishes us with instances of bishops consecrated without having passed the order of priesthood; and Panormus still thinks that such an ordination is valid.

Orders ‖ Ordinary.

Military ORDERS are companies of knights, instituted by kings and princes, either for defence of the faith, or to confer marks of honour and grant distinctions to meritorious subjects.

Religious ORDERS are congregations or societies of monastics, living under the same superior, in the same manner, and wearing the same habit. Religious orders may be reduced to five kinds, namely, monks, canons, knights, mendicants, and regular clerks. Father Mabillon shows, that till the ninth century, almost all the monasteries in Europe followed the rule of St Benedict; that the distinction of orders did not commence till after the reunion of several monasteries into one congregation; that St Odo, abbot of Cluny, first began this reunion, bringing several houses under the dependence of Cluny; and that, a little afterwards, in the eleventh century, the Camaldulians arose, then the congregation of Vallombrosa, the Cistercians, Carthusians, Augustines, and at last, in the thirteenth century, the Mendicants. He adds, that Lupus Servatus, abbot of Terrières, in the ninth century, is the first who seems to distinguish the order of St Benedict from the rest, and to speak of it as a particular order.

White ORDER denoted the order of regular canons of St Augustin.

Black ORDER denoted the order of Benedictines.

These names were at first given to the two orders in question, from the colour of their habit; but were disused after the institution of several other orders, who adopted the same colours.

Gray ORDER was the ancient name of the Cistercians; but, since the change of the habit, the name is no longer applicable.

ORDERS, religious military, are those instituted in defence of the faith, and privileged to say mass; but who are prohibited marriage, and subjected to other restraints.

Of this kind were the knights of Malta, or of St John of Jerusalem, the Knights Templars, the knights of Calatrava, the knights of St Lazarus, the Teutonic knights, and various others.

ORDINAL NUMBERS, those which express order, as 1st, 2d, 3d, 4th, and so on.

ORDINANCE, or ORDONNANCE, means a law, statute, or command of a sovereign or superior. Thus the acts of parliament are sometimes termed "ordinances of parliament," as in the parliament rolls; although in some cases we find a difference made between the two, ordinances being only temporary things, by way of prohibition, and capable of being altered by the commons alone, whereas an act is a perpetual law, and cannot be altered except by king, lords, and commons.

Coke asserts, that an ordinance of parliament differs from an act, as the latter can only be made by the threefold consent of the estates; whereas the former may be made by one or two of the estates.

In the French jurisprudence, ordonnances are such laws as are established by the king's authority alone.

ORDINARY, in general, signifies common, usual. Thus, an ambassador, or envoy, in ordinary, is one sent to reside statedly, and for a number of years, at the court of some foreign prince or state, in order to keep up a good understanding, and watch over the interest of his own nation.

ORDINARY, in nautical language, denotes the establishment of the persons employed by government to take charge of the ships of war which are laid up in the several harbours adjacent to the royal dock-yards. These are principally composed of the warrant officers of the said ships, as the gunner, boatswain, carpenter, deputy-purser, and cook, with three servants. There is, besides, enrolled in

Ordinary || Ordonnance.

the list of the ordinary, a crew of labourers, who pass from ship to ship occasionally, to pump, moor, remove, or clean them, whenever it is necessary.

The term *ordinary* is also applied sometimes to the ships themselves; and it is likewise used to distinguish the inferior sailors from the most expert and diligent. The latter are rated *able* on the navy books, and have higher pay than those who are rated as *ordinary*.

Ordinary of Assizes and *Sessions*, was a deputy of the bishop of the diocese, anciently appointed to give malefactors their neck-verses, and judge whether they read or not; to perform divine service for them, and assist in preparing them for death.

Ordinary of Newgate, is one who attends in ordinary upon the condemned malefactors in that prison, to prepare them for death, and who records the conduct and behaviour of such persons.

ORDINATES, in *Geometry* and *Conics*, are lines drawn from any point of the circumference of an ellipsis, or other conic section, perpendicularly across the axis, to the other side.

ORDINATION, the act of conferring holy orders, or of initiating a person into the priesthood, by prayer and the imposition of hands.

Ordination has always been esteemed a principal prerogative of bishops, and they still retain the function as a mark of spiritual sovereignty in their diocese. The ordination of bishops is properly called *consecration*. Ordination is one of the sacraments of the church of Rome. In the established church of Scotland, where there are no bishops, the power of ordination is lodged in the presbytery; and by the Independents, in the suffrage of the people.

ORDNANCE, a general name for all sorts of great guns used in war.

Master-General of the Ordnance is deemed the principal officer in the civil branch of the ordnance; yet he is always chosen from amongst the first generals in his majesty's service.

Lieutenant-General of the Ordnance receives all orders and warrants signed by the master-general, and from the other principal officers, and sees them duly executed; issues orders as the occasions of the state require; and gives directions for discharging the artillery when required at coronations, birth-days, signal victories, and other solemn occasions.

Surveyor-General of the Ordnance inspects the stores and provisions of war in the custody of the storekeeper, and sees that they are ranged and placed in such order as is most proper for their preservation.

Clerk of the Ordnance, an officer whose function is to record all orders and instructions given for the government of the office; all patents and grants; and the names of all officers, clerks, artificers, gunners, labourers, and the like.

Storekeeper of the Ordnance takes into his custody all his majesty's ordnance, munitions, and stores belonging thereto, and indents and puts them in legal security, after they have been surveyed by the surveyor-general, any part of which he must not deliver without a warrant signed by the proper officers.

Clerk of the Deliveries of the Ordnance draws all orders for delivery of any stores, and sees them duly executed.

Treasurer und Paymaster of the Ordnance receives and pays all moneys, both salaries and debentures, in and belonging to this office.

ORDONNANCE, in architecture, is the composition of a building, and the disposition of its parts, both with regard to the whole and to one another; or, as Mr Evelyn expresses it, determining the measure of what is assigned to the several apartments. Thus ordonnance is the judicious contrivance of the plan or mould; as when the court, hall, or other building or apartment, is neither too large nor too small, and that the court affords convenient light to the apartments around it, the hall is of a fit capacity to receive company, and the bed-chambers of a proper size. When these divisions are either too great or too small with respect to the whole, as where there is a large court to a little house, or a small hall to a magnificent palace, the fault is in the ordonnance.

Ordonnance || Oregon.

ORDONNANCE, in *Painting*, is used for the disposition of the parts of a picture, either with regard to the whole piece or to the several parts, as the groups, masses, contrasts, and so forth.

ORE, a mineral body, partly or entirely composed of some metallic substance, in the natural state in which it exists in the earth. Metallic substances are found either native, that is, pure, and uncombined with other substances, or alloyed with other metals, or combined with oxygen or sulphur, or with acids. Thus it appears that metals exist in ores in four different states; in the metallic state, when they are either pure, or combined with each other, as in the state of alloy; in the state of an oxide; combined with sulphur in the state of sulphuret; and, with acids, forming salts.

OREEHOUA, one of the smaller Sandwich Islands, which is a single high hummock, and is only separated from Onehow by a channel about a mile in width. The population is 4000.

OREGON Territory, a vast extent of country belonging to the United States of North America, and situated to the west of the Rocky Mountains. It is bounded on the north by the British and Russian possessions, the limits of neither power having been very clearly fixed. On the west it is bounded by the Pacific; on the south by Mexico; and on the east by the stupendous ridges of the Rocky Mountains, situated in the territories of Arkansas and Missouri. It may be assumed as stretching between the forty-first and fifty-fourth parallels of north latitude, and the thirty-fourth and forty-eighth meridians of west longitude. The waters which rise on the western declivities of the gigantic mountain chain bounding Oregon on the east, flow into the Columbia, the Multnomah, and the lake Buenaventura. In general the elevated summits of the Rocky Mountains rise above the line of perpetual congelation. Beyond the mountains the country descends by regular belts, in the form of immense terraces, or descending plains, disposed regularly, the one below the other. Beyond the first plain, and between the Rocky Mountains and the Pacific, is another extensive and high chain of mountains, in which are the great falls of the Columbia; still farther to the west, running parallel with the coast, and at the distance of one hundred and fifty miles, is the third and last chain. The peaks of all these mountain ridges are covered with perpetual snow. The loftiest of them have been named Mount Baker, Mount Regnier, Mount St Helens, Mount Hood, and Mount Jefferson.

The Columbia and its branches are the only rivers which have been explored to any extent in the region of Oregon. This noble river, sometimes named after the territory, has its head waters near those of the Missouri, and it collects innumerable tributary streams throughout a great extent along the western ridges of the Rocky Mountains. Immediately after it emerges from these, its current becomes broad and deep, and having received Clarke's and Lewis' Rivers, which flow into it on the south-east side, its breadth is enlarged to nine hundred and sixty yards. It there takes a great bend to the south, and penetrates the second mountain barrier. One hundred and thirty-six miles lower down are the great falls, where the river descends fifty-seven feet in one rapid; but none of the cataracts singly are above twenty feet. Below these falls it winds first to the north-west, and then to the south-west, and intersects the third

Oregon. chain of mountains, where it is again compressed to one hundred and fifty yards in breadth. Below this rapid, which is distant one hundred and eighty miles from the Pacific, it meets the tide, and from this point it has a broad estuary to the sea. Sixty miles below the rapids, the Wallamat or Multnomah, a large tributary, flows in from the north-east; and this river, together with those of Clarke and Lewis, constitute the three great tributary streams of the Columbia. Vessels of three hundred tons may reach the Multnomah, and large sloops may ascend as high as the tide. Above the rapids the navigation is good for sixty-five miles, when it is interrupted by the long narrows; and higher up it is also interrupted by falls, which renders about five miles of portage necessary to obviate these obstructions to navigation. The river at the narrows, for upwards of three miles, is compressed into a strait, not exceeding sixty or seventy yards in breadth, the whole of which is a succession of boiling whirlpools. The Columbia flows into the Pacific Ocean in latitude 46. 19. north, and longitude 123. 54. west; and although its main sources are estimated at only eight degrees of latitude from this, yet if we take into calculation its serpentine windings, its course cannot be less than fifteen hundred miles. The mouth of this great river is upwards of four miles wide, and, to the distance of thirty or forty miles from its entrance into the sea, it is, properly speaking, a mere estuary, indented by deep bays, so as to vary from three to seven miles in width. It is rendered extremely intricate and dangerous by shoals reaching nearly from shore to shore, on which at times the winds and currents produce foaming and tumultuous breakers. The river proper, however, is only about half a mile wide at its confluence with the sea, being narrowed by the contracting shores of the estuary. The entrance from the Pacific is bounded on the southern side by a flat sandy neck of land, stretching into the ocean, and commonly called Point Adams. The opposite or northern side is Cape Disappointment, a kind of peninsula, terminating in a steep knoll or promontory, crowned with a forest of pine-trees, and connected with the mainland by a low and narrow neck. The Columbia River is, for a considerable distance, seldom less than a mile in breadth; in some places it is from two to five miles wide, and in others it forms lakes of very considerable magnitude. The shores are generally bold and thickly wooded. Pine in all its varieties predominates, and is mixed with white oak, ash, beech, poplar, alder, crab, and cotton wood, with an undergrowth of briars and other shrubs. Up to the rapids the river is covered with numerous islands, from one to three miles in length, some of which present fine meadows, and others are well wooded. Sand banks also prevail, and these, being so large and high as to be laid bare at low water, materially obstruct the navigation of the river. In the neighbourhood of these the shores are generally low, and present some fine flat "bottoms" of meadow ground, bordered by a profusion of blackberry and other wild-fruit shrubs; in the deep and narrow parts of the channel the shores are bolder. The pine-tree declines considerably above the rapids, and is much more equally mixed with other trees, amongst which the hazel occasionally predominates. But in regard to size, the pine and the cedar are as gigantic at the very source of the Columbia as they are on the shores of the Pacific. The Columbia and its tributaries abound with the finest salmon, which seem in fact to constitute the principal article of food of the savages who inhabit the country to the west of the Rocky Mountains. Seals and other aquatic animals are likewise abundant in this river, and the skins, which are exported to China, constitute the chief article of trade. A number of the head streams of the Missouri interlock with the waters of this river, as Wisdom River with Clarke's of the Columbia; and Jefferson of the Missouri with Lewis's of the Columbia. Clarke's River has a course of between two and three hundred miles before it unites with the Columbia. Lewis's River is also a large and long tributary, receiving in its course the North Fork and Kooskooskee, and, after winding six hundred miles, it joins the Columbia by a mouth upwards of six hundred yards in width. The current is very rapid. Its waters are deep, of a white colour, and slightly tepid, in which respect Lewis River forms a marked contrast with the Columbia, the waters of which are quite clear and cool. The latter river at this place is upwards of one thousand yards wide, and the current descends at an even rate of about four miles an hour. The two most important rivers which join the Columbia below the rapids are, the Multnomah, which has been already mentioned, and the Coweliskee. The general course of the former is a little to the eastward of south. It runs through a low, well-wooded country, for upwards of sixty miles, when the navigation is interrupted by a considerable fall, above which the channel contracts, and the banks become higher and less wooded. The climate on the shores of this river is remarkably mild, and not so moist as it is on the coast. It possesses a rich and luxuriant soil, which yields an abundance of fruits and roots; and amongst other herbs the tobacco plant has been discovered, and found to be of excellent quality. The Indians here are of a pacific character. There are no noxious reptiles, and beaver, deer, and elk are plentiful. Indeed it is anticipated, that when Oregon shall become generally colonized, the country about the Wallamat will be rendered one of the most delightful districts to the westward of the Rocky Mountains. Little is known of the Coweliskee. It enters the Columbia from the northward, about half a day's journey below the Wallamat. Its banks are high and thickly wooded, but its current is much interrupted by rapids. Oregon.

Little information has been obtained regarding the geological features of this vast expanse of country; but it is presumed that the western declivities of these mountains are of primitive formation. The territory must have an abrupt slope towards the Pacific, as it descends as much in six hundred miles to the west, as it does in one thousand five hundred miles to the east. The summits of the mountain ranges, being rugged rocks, the only covering of which is snow, that remains during the greater part of the year, are necessarily sterile; but these rocky chains embosom and shelter valleys of considerable fertility. The timber which clothes the mountains consists of pine, spruce, fir, and the other terebinthines. The terrace plains below have in general a fine soil, but they are very scantily furnished with timber, except on the banks of the rivers. The prairies are covered with grass and a profusion of beautiful flowers, the same as on the eastern sides of the mountains. Amongst the prairie plants are found various species of edible roots, which are used by the savages, in addition to the immense quantities of salmon, which constitute their staple article of food. Wild sage is not only a most abundant herb, but it grows to so large a size that it is used as the chief article of fuel on these extensive plains. Deep and thick forests of such evergreens as pine and hemlock stretch along the shore, and extend a considerable way into the interior; and altogether it appears that the region which lies between the Rocky Mountains and the Pacific Ocean possesses in many parts a fertile soil, besides enjoying an agreeable climate. Its southern border, where it joins with Mexico, is indeed remarkably mild. In the year 1805 this region was explored by order of the American government; and from the tables which were drawn up by Lewis and Clarke, the persons employed on that service, a pretty correct idea may be formed of the meteorology, and consequently of the climate, of the country in question. From September it gradually became colder till the end of January, after which the rigour of the winter abated, and by the end of

Oregon. February it was "quite warm." By the middle of March plants appeared above ground, and put forth their leaves; and on the 30th of that month, "grass was sixteen inches high in river bottoms." It is not, however, till the end of May that snow disappears from the high plains; and about the beginning of June the river Columbia is at its greatest height, being swelled by the melting of the snow on the mountains. Strawberries are ripe at the end of this month, and July and August appear to be the season when fruits and flowers arrive at full perfection. From other and more recent authorities we learn that the summer is reckoned temperate, the thermometer never rising above eighty degrees. Westerly winds prevail during the spring and early part of summer, and they are succeeded by fresh breezes from the north-west. In the month of October the southerly winds set in, bringing with them frequent rain. The rainy season, which commences in this month, continues, with little intermission, till April; and although the winters, as we have already observed, are mild, the mercury in the thermometer seldom sinking below the freezing point, yet the tempests of wind and rain are terrible. The sun is said to be sometimes obscured for weeks, the brooks swell into roaring torrents, and the country is threatened with a deluge.

The foregoing observations regarding the climate, soil, and productions of Oregon, apply chiefly to that part of the country which lies between the rapids and the Pacific Ocean. Mr Ross Cox, who spent several years in this region, informs us, that from the falls to the land of the Spokans, a distance of about five hundred miles, the summers are excessively hot, and the winters intensely cold, yet the climate is withal remarkably healthy, and, during these seasons, subject to but little variation. The soil is unproductive, consisting chiefly of a light yellowish sandy clay. The plains are covered with a short kind of grass, mixed with prickly pears, wormwood, and tufts of long, coarse grass, from three to five feet in height. Patches of clover are here and there visible, and in their vicinity the chappallel and the camas or quamash roots are found. Wild onions grow in considerable quantities along the banks of the river above the falls. Cotton wood, small willow, sumac, furze, and sarsaparilla, are also occasionally found; but from the falls to Spokan River, none of the larger trees are met with. The principal animals are horses, small deer, prairie wolves, red foxes, badgers, polecats, hares, and dogs. Otters are sometimes seen; but the great staple animal of the American trapper, the beaver, is a stranger to this particular district, whilst in other parts of the country it is frequently found. The Indians affirm that buffaloes were formerly numerous, but, together with the elk and the sheep, they have long since deserted the plains. No rattle-snakes are seen below the falls; but at a short distance above them they make their appearance, and are in some parts very numerous, as are also horned lizards and grasshoppers. Within the region of the Rocky Mountains vegetation on the Columbia is rich and luxuriant, including all the varieties, from a profuse growth of blackberry and wild cherry, to the stately pine and majestic cedar. On the eastern side of the mountains, the reverse of this is observed, vegetation being dwarfish and stunted. The difference is supposed to arise from the great humidity of the atmosphere on the Columbia. There, westerly and south-westerly winds prevail during eight months of the year, and are loaded with exhalations from the Pacific. Such of the clouds as are not arrested by the high lands on the coast, are stopped in their progress eastward by the lofty chain of the Rocky Mountains, and thus serve to keep the climate perpetually moist.

In the year 1811, a settlement was formed by American citizens at the mouth of the Columbia, and called Astoria, after Mr Astor, who conceived the idea of forming an extensive fur dépôt in this part of America. Astoria was taken by the British in 1813, and by them the name of the place was changed to that of Fort George. The soil and productions of this portion of the Oregon territory are thus described by Mr Ross Cox. "The soil in the valleys consists of a bed of rich black mould, about six inches in depth, which covers a stratum of gray earth, extremely cold. The latter lies on a layer of large gravelly sand; and under all is a bed of hard flinty stones. On the high grounds, under a thin covering of black mould, are found good quarry stones, well adapted for building. There is a bank of white earth, resembling chalk, to the southward of Point Adams; and farther on in the same direction, the Indians find red, green, and yellow earths, and a species of heavy shining clay resembling lead-mine. No limestone is found in the neighbourhood." In June there are, amongst other wild fruits, small white strawberries, of a sweet flavour; and these are followed by red and amber raspberries, which grow upon bushes from ten to fifteen feet in height. During the three months which follow, there are obtained considerable quantities of blueberries, blackberries, wild cherries, gooseberries, wild pears, and a species of bitter crab-apple. There is a shrub of a peculiar description, which yields a fruit much esteemed by the natives. The country likewise abounds in various nutritive roots, amongst which is a kind resembling young onions, collected by the Indians in great quantities, which, after being dried and pulverized, are made into loaves, and laid up for seasons of scarcity. The principal quadrupeds are the elk, the red deer, the black-tailed deer; the black, brown, and grizzly bear, the last of which is extremely ferocious; the wolf, lynx, panther, tiger-cat, wild cat, marmot, fox, beaver, land-otter, sea-otter, musk-rat, wood-rat, and the horse. White bears are occasionally killed on the coast to the northward of the Columbia, but they are scarce. The most remarkable of the feathered tribes are the black, brown, and nun eagle, the hawk, pelican, cormorant, swan, heron, crane, bustard, gray and white goose, various species of wild duck, and other water-game. In some parts, the humming-bird and bee, in great numbers, banquet during the summer months amongst the wild flowers and aromatic herbs. The trees most common in the neighbourhood of Astoria are the cedar, spruce, pine, alder, and some others equally valuable. The cedars are from twenty to thirty feet in circumference, and proportionally high. The alders also are extremely large; and ash and oak, the former of a tolerable size, are found a few leagues above the fort.

The rivers and the lakes are most abundantly furnished with fish of various kinds. In the spring months they swarm with immense quantities of small fish resembling pilchards, which are smoke-dried, and form an important article of barter with the upper Indians for roots. Prime sturgeon, which attains an enormous size, abound in the months of August and September; but the grand staple is salmon, the chief fishing of which is at the "long narrows," already mentioned, where the river, compressed into a channel from fifty to one hundred feet in breadth, boils and roars with great fury for a distance of three miles. In the spring of the year, when the water is high, the salmon ascend the river in incredible numbers. As they pass through this narrow strait, the Indians, standing upon the rocks, or on the end of wooden stages projecting from the banks, scoop them up with small nets distended on hoops, and attached to long handles, and cast them ashore. They are then cured and packed in a peculiar manner. After being disembowelled, they are exposed to the sun on scaffolds erected on the river-banks. When sufficiently dry, they are pounded fine between two stones, pressed into the smallest compass, and packed in baskets or bales of grass matting, about two feet in length and one in diameter,

Oregon. lined with the cured skin of a salmon. Packages are then made, each containing twelve of these bales, and being well wrapped up and secured, they are placed in dry situations, and again covered with matting. Each of these packages contains from ninety to a hundred pounds of dried fish, which in this state will keep sound for several years. At the head of the long narrows the Indians had some years ago, and have still, it is presumed, their principal trading mart or emporium. Here the salmon caught in the neighbouring rapids are "warehoused," to await customers. Hither the tribes from the mouth of the Columbia repair with the fish of the sea-coast, the roots, berries, and especially the wappatoo, gathered in the lower parts of the river, together with goods and trinkets obtained from the ships which visit the coast, or from the colonists. Hither also the tribes from the Rocky Mountains bring down horses, bear grass, quamash, and other commodities of the interior. The trade is of course pursued on the primitive principle of barter, the merchant fisherman acting as middleman or factor.

Although only a comparatively small portion of Oregon, and that chiefly situated on the banks of the great river, has been described, the greater part of the territory being still an unexplored wilderness, yet from this partial account we are induced to form a favourable opinion of the country. Wood appears to abound on the banks of the rivers, but many of the immense prairies of which the interior principally consists are nearly destitute of it, being chiefly covered with a coarse grass, and a prodigious growth of prickly pear, and other shrubs. Occasionally, however, there intervene bright green patches intermixed with wild flowers, and gently rising eminences, partially covered with clumps of small trees, which give an agreeable variety to the face of the country. Lewis and Clarke give a very pleasing account of what they term the great Columbian valley. It is sixty miles in width, and extends far to the south-south-east, between parallel ridges of mountains, which bound it on the east and west. Through the centre of this valley flows the Wallamat, which has already been described as traversing for several hundred miles a still unviolated wilderness. The sheltered situation of this immense valley has an obvious effect upon the climate, as might be expected. It is represented as a region of great beauty and luxuriance, with lakes, and pools, and green meadows, shaded by noble groves. Various Indian tribes are said to reside in this valley, and all along the banks of the Wallamat. There is another place called Oakinagan, of which Mr Ross Cox gives a very flattering description. It is a point of land three miles in length by two in breadth, formed by the confluence of the river Oakinagan with the Columbia. This small spot is enclosed at the upper end by a chain of hills, within which the rattlesnakes never intrude. The climate here is highly salubrious, the soil is fertile, producing immense quantities of sarsaparilla; the horses are abundant, and ample facilities exist for water-carriage. The native Indians who inhabit the peninsula are an honest, quiet, inoffensive tribe, whose chief occupation is catching and curing salmon, and hunting the deer and beaver. This was reckoned an eligible situation for a fort, and here one has accordingly been erected.

There is a district called New Caledonia, generally included in the territory of Oregon, of which a short account is requisite in this place. It extends from north latitude 51° 30′ to about 56°. The principal trading post is called Alexandria, which is built on the banks of Fraser's River, in latitude 53° north. The country in its immediate vicinity presents a beautiful and picturesque appearance. The banks of the river are somewhat low; but at a little distance inland, elevations, partially diversified by groves of fir and poplar, raise their heads above the general level. This region is full of small lakes, rivers, and marshes. It extends about ten days' journey in a north and north-east direction. To the south and south-east the Atnah or Chin Indian country extends about one hundred miles; on the east there is a chain of lakes, and the mountains bordering Thompson's River; whilst to the westward and north-west lie the lands of the Naskotins and Clinches. The principal rivers are Fraser's, Quesnel's, Rough Poplar, Chilcotin, and West Road. Of these, Fraser's River only is navigable. It receives the waters of Quesnel's and West Poplar Rivers, which issue from small lakes to the westward. The lakes and rivers abound in fish, such as salmon, trout, sucker, and the like. The soil is thin and poor, and the vegetation here is considerably inferior to that on the Columbia. On the banks of the chief river, and in the interior, the trees consist of poplar, cypress, alder, cedar, birch, and different species of fir, spruce, and willow. There are some wild fruits, and edible and medicinal roots, but not at all so plentifully distributed as in other parts of the territory. A number of valuable minerals are found in New Caledonia, including coal in considerable quantities. There have also been discovered rock-crystal, cobalt, talc, iron, marcasites of a gold colour, marble and limestone, quartz and granite. The animal kingdom does not differ so much from that which characterises the banks of the Columbia, as to require specific mention. Spring commences in April, when the wild flowers begin to bud, and from this period to the latter end of May the weather is delightful. In June it rains incessantly, with strong southerly and easterly winds. During the months of July and August the heat is very great; and in September the fogs are so dense that it is quite impossible to distinguish the opposite side of the river any morning before ten o'clock. October gives indications of the approach of winter; and in January the cold is sometimes most intense. In general, however, the climate may be characterised as neither unhealthy nor unpleasant. The natives prosecute the salmon fishery to a considerable extent, and their mode of catching them is very similar to that already described. Large-sized sturgeon are occasionally taken, but this fish is not relished by the natives. Oregon.

Of the various Indian tribes who still inhabit the immense tract of country which we have described, our limits permit us to present only a very brief notice. Their number has been estimated at about 140,000, and they are distributed into a great many tribes, which often engage in war with each other. Many of them are excellent hunters; and the mode of fishing and preparing the article for the market shows a practised ingenuity seldom evinced by the aborigines of America. There are striking contrarieties of character between the Indian tribes; some of them being pugnacious and bloodthirsty, and others of a comparatively mild and inoffensive disposition. Their diet and their mode of living also vary considerably, but they all chiefly subsist on the fish of the rivers, and the native roots of the soil. For some years a settlement of fur traders, called Astoria, has existed in Oregon. The chief intercourse of this place is with China. The question of settling this delightful country permanently has been more than once debated in Congress; and were such settlements authorized, and rendered secure by the requisite military establishments, there can be no doubt but it would receive large accessions of emigrants. This region is claimed by the United States, on the ground of priority of discovery, examination, and occupation. It was certainly first discovered by the Spaniards, but they made no attempt either to explore or settle it. Its rediscovery belongs to Gray, an American, who entered the mouth of the Columbia in 1790–1, the river being called after the ship which he commanded. Subsequently it has been explored by navigators belonging to Great Britain, as well as to the United States. (R. R. R.)

Orel ‖ Orenburg.

OREL, or ORLOW, a government of Russia in Europe. It is situated in north latitude between 51. 49. and 54. 59. and in east longitude between 32. 49. and 38. 57., and extends over 16,610 square miles. It is divided into twelve circles, and contains 1,270,000 inhabitants. It is rather a level district, having no mountains, and only some ranges of chalk hills, between which are valleys and some woods, that render the face of the country more pleasing to view than most other parts of Russia. The rivers and rivulets are numerous, and empty themselves, some into the Wolga, and others into the Dnieper. The chief of the streams is the Desna, which arises in the province of Smolensko; and the next is the Oka, which originates in Kursk, and runs through the whole province. The soil is the most fruitful of any of the ancient divisions of Russia, and, though not well cultivated, yields crops of all the common grains, more than is required for domestic consumption. The surplus of corn, as well as spirits distilled from it, forms a branch of the export trade; but it is exceeded by the manufactured goods, which consist of linen, iron, and steel articles, raw hides and leather, tallow and soap, glass wares, hemp, flax, linseed oil, mats, butter, hams, and wool. The only mines are those of iron; but there are quarries of alabaster, and some yielding excellent millstones. Orel, the capital of the government, as well as of the circle in which it stands, is a city situated on the banks of the river Oka, at the spot where the Orlik joins that stream, and becomes navigable for barges. It is the seat of a bishop, and is surrounded by palisades, and protected by a citadel. It is a gloomy city, built chiefly of wood, and contains 2871 houses, with about 20,000 inhabitants, depending on the trade, which, from the whole province, centres in it. It is 732 miles from St Petersburg. Long. 35. 52. 2. E. Lat. 52. 56. 40. N.

ORELLANA, FRANCISCO, the first European, as is commonly thought, who discovered the river Amazons. In 1539, he embarked, near Quito, upon the river Coca, which farther down takes the name of Napo. From this he fell in with another large river; and, leaving himself entirely to the direction of the current, he arrived at Cape North, on the coast of Guiana, after sailing nearly eighteen hundred leagues. Orellana perished ten years afterwards, with three vessels which had been intrusted to him in Spain, without being able to discover the mouth of this river. In sailing down the river, he met with some armed women, against whom an Indian cacique had told him to be on his guard; and he thence named it "the river of the Amazons."

ORENBURG, a government of Asiatic Russia, the most westerly of the whole, having on one side Russia in Europe, and on the other the government of Tobolsk. It is bounded on the south by Independent Tartary, and is traversed by the rude tribes of the Kirghisses and Kalmucks. The aspect of the country is mountainous, as it is intersected by the most elevated part of the great Uralian chain. Many parts are fertile, as the valleys and river banks, and yield grain, not merely for the subsistence of the natives, but for exportation. Numerous flocks and herds are fed on the abundant pastures; and even the camel is bred upon the plains. The breeding of bees is pursued with activity, and is found an extremely profitable branch of industry. A great quantity of large fish and caviar taken in the Ural are exported. This province is rich in mineral wealth. Its mountains afford inexhaustible mines of copper and iron; besides which, it contains saline lakes, which are very valuable. It is divided into twelve districts, of which the principal are Orenburg proper and Oufa, the last of which contains the capital. On the Tartar frontier this province is exposed to the incursions of the Kirghisses and the Kalmuck hordes, against which a chain of forts has been erected. The population is stated at 629,426.

Orenburg ‖ Orestes.

ORENBURG, the capital of the province above described until 1702, when the government was transferred to Oufa. It is a considerable town, of an oval form, situated in one of the extended plains of Russia, and regularly fortified. It was originally built higher up the Ural range, but in 1739 was transferred 120 miles lower, and in 1742 fifty miles more. It contains nine churches and 2000 houses. It carries on an extensive trade with Tartary, Bukharia, and all the countries in the interior of Asia. One great drawback on this trade is the insecurity of travelling across the vast intervening steppes, which are inhabited by nomadic tribes, who subsist by plunder. Were this obstacle removed (and the influence of the Russian government has gone far to remove it), the trade must greatly increase. The exports consist of cloths of different qualities, particularly of a red or scarlet colour, velvets, Russia leather, linens blue and white, copper and iron utensils, sugar and other colonial produce, toys, and glass, and various species of ornaments. From Tartary these caravans bring cotton wool, India muslins and cottons, Persian silks, a little gold dust, lapis lazuli, and a few precious stones. Sheep to the number of 40,000 or 60,000, and horses to the amount of 10,000, are brought annually to the market of Orenburg. The horses are sent to Russia, and also the sheep, the tallow of which is exported from St Petersburg. A considerable trade is carried on in the sale of golden eagles, which are highly valued by the Kirghisses. Long. 52. 31. 10. E. Lat. 51. 46. N.

ORENSE, a city of Spain, in the province of Galicia. It is situated in the higher part of the country, through which the Minho flows, over which there is a magnificent bridge. It was known to the Romans by the name of Aqua Calida, on account of three fountains of warm water which rise near it. It is situated in a very fertile district, which produces great quantities of wine; but, from the bad state of the roads, the expense of conveying it to a market is more than it would sell for when it arrived there. Orense is the see of a bishop, whose spiritual jurisdiction extends over a part of the contiguous province in Portugal. It possesses four churches, two monasteries, an hospital, and a population of 30,000 souls.

ORESTES, the only son of Agamemnon and Clytemnestra, was seven years old at the period of his father's murder, when he was saved by his sister Electra, who sent him secretly to Strophius, prince of Phocis, who had married the sister of Agamemnon. Here he was educated with Pylades the son of Strophius, and afterwards proceeded to Athens. Eight years after the murder of his father he returned to Mycenæ, and, with the assistance of Pylades and Electra, put to death Ægisthus and Clytemnestra (Hom. *Od.* i. 298; iii. 303–310; Hygin. 117). For this barbarous deed he was brought to trial, but was allowed to escape on account of his father. Tyndareus, father of Clytemnestra, was his accuser (Hygin. 119), or, according to another tradition, Perilaus, son of Icarius, and cousin of Clytemnestra (Paus. viii. 33, 2). He fled to Epirus, and there founded the city Argos Oresticon; but the district of Orestias is more properly in Macedonia (Strab. vii. 326). Suffering extremely from the stings of his conscience, he consulted the oracle of Delphi how he might best expiate his crime, when he was commanded to proceed to Tauris and to bring back the statue of Artemis or Diana Tauropolos. There was a law in that country that all strangers should be sacrificed to the goddess; and when Orestes and Pylades were found by some shepherds, they were brought to Thoas, king of Tauris, who ordered them to be delivered up to the priestess of Artemis, that they might be sacrificed. Iphigenia, the sister of Orestes, had been rescued from the altar when she was on the point of being sacrificed by orders of her father, and transferred by Artemis to be priestess in her temple in Tauris. Iphigenia

Orfa.

discovered on inquiry that the strangers were her own brother and his friend, and assisted them in carrying off the statue (Hygin. 120). Upon their return they are said to have passed through Cappadocia, and to have instituted the worship of Artemis or Diana at Comena and Castabela (Strab. xii. 535, 537). Another tradition made him be expiated by the Trœzenian (Paus. ii. 31, 11). On the death of Menelaus, Orestes became king of Lacedæmon; and on the failure of the royal line of Megephenthes at Argos, he annexed that city to Mycenæ. He also acquired a great part of Arcadia, and was assisted by the Phocians (ii. 18, 5). In the latter part of his life he retired to Arcadia, and probably died by the bite of a serpent (Schol. Lycoph.) at Megea, whence his bones were afterwards transferred, in the reign of Anaxandrides, to Sparta (iii. 11, 8; Herodot. i. 67). He was married to Hermione, daughter of Menelaus and Helen, by whom he had Tisamenos, who succeeded him (Hygin. 122); and by Erigone, daughter of Ægisthus and Clytemnestra, he had Penthilus (Schol. Lycoph. 1374).

ORFA, or OURFA, a pachalik or division of Asiatic Turkey. It is almost entirely formed by the windings of the Euphrates and the river Khabour, and occupies a considerable portion of the most barren part of Mesopotamia. It touches on the north and east the pachalik of Diarbekir, and the dependencies of Malatea; and on the south and west it is separated by the Euphrates from the deserts of Syria. The southern part of this province is, for the most part, flat, sandy, and uncultivated, and inhabited by tribes of wandering Arabs, who pitch their tents on the banks of the rivers and in the vicinity of the springs; but towards the north the country is mountainous and better inhabited. In the early ages of the Roman empire this division of Mesopotamia bore the name of Osrhoene, and had subsisted for 840 years as an independent kingdom, when it was reduced into the form of a Roman province by the Emperor Caracalla. It was finally swallowed up in the Turkish empire. The principal towns are Orfa, Racca, and Soverick.

ORFA, a large town, and the capital of a pachalik of the same name, in Asiatic Turkey. It is situated on the eastern side of a hill, at the commencement of a plain; so that whilst its western extremity stands on elevated ground, the eastern quarter of the town stands on a lower level; and, with some trifling inequalities, the whole town may be said to be nearly flat. It is surrounded by a stone wall, which encloses a circuit of from three to four miles, in the form of an irregular triangle; and it is bounded on the west by modern burying-grounds, gardens, hills, and vales, on the south by a rising ground, on the east and south-east by a fertile plain, terminating at the foot of a bare ridge of hills, and on the south-west is a hill nearly overlooking the town, and crowned with the walls of a ruined castle. The houses are well built, and of good masonry; they have mostly a small door of entrance from the street, with an open court, and divans in recesses below, whilst the upper story is laid out in public rooms more expensively furnished. Above is the terrace, on which are placed sofas and beds, where, in hot weather, the family sleeps. The streets are narrow, but having a paved causeway on each side, with a central channel for water, and being more or less sloping downwards, are generally clean. The bazaars are numerous and well supplied, and are appropriated to the manufacture and sale of particular commodities. Most of these are commodious; they are also covered, and are always fresh and cool, being sheltered both from the sun and rains. The bazaar in which muslins, cottons, and other piece goods are exposed, is from twenty to twenty-five feet in width, and from thirty to forty feet in height, covered in by a range of fine domes in succession, admitting light and air by a sort of lantern windows in the roof. The khans and caravanserais are numerous, and some few are excellent. The Khan Khoolah-Oghlee, on the outskirts of the town, is spacious, and capable of accommodating in its central court 100 camels with their lading, in the adjoining stables as many horses, mules, and asses, and in the chambers above there is room for 200 persons. The Khan-el-Goomrook, or the custom-house khan, consists of an open court 100 feet square, and paved throughout. Through this court runs a fine broad stream of transparent water, crossing it diagonally, and serving for the watering of horses, the ablutions of the pious, and the washing and cleaning of manufactures. There are, above and below, about 100 chambers large enough to accommodate eight or ten persons each. There are fifteen mosques crowned with minarets. The most magnificent of these, though not the largest, is that of Ibrahim el Khaleel, or the mosque of the patriarch. It is situated on a lake filled from a clear spring which runs in the south-west quarter of the town, and abounds with fine carp, in which the superstitious people believe that, owing to the care of the patriarch, no impression can be made by any process of cooking. The grand façade of this mosque is a square pile of building, over which rise three large domes of equal size; and a lofty minaret springs up from amidst a cluster of tall cypress trees. At each end of this central pile, towards the stream, are flights of steps descending to the water's edge, for the ablutions of the pious. The wings are terminated by two solid masses of building, uniform in design, and "completing," says Buckingham, "one of the most regular edifices of this kind to be found perhaps in Turkey." The largest of the mosques at Orfa has a square steeple, and this form is also repeated in one of the smaller ones. The castle is on the south side of the city; the ascent is very steep, and is about half a mile in circumference, surrounded by a deep ditch cut in the rock, which can be filled with water from the river Scirtus. On this rock are the ruins of a building called by the Arabs the palace of Nimrod, consisting of two lofty and fine Corinthian pillars, and of some subterranean apartments, apparently of great antiquity. There are four or five large baths, some reported to be good; but the one which was seen by Mr Buckingham was, though spacious, dirty and badly attended. The manufactures of the town are chiefly confined to articles of the first necessity, namely, to coarse woollen cloths, used for shirts and drawers, and, when printed, made into gowns for females, shawls for the head, and some other articles. The process used for printing cottons is tedious. A few carpets are made, of a very good quality, also silk bands and tapes, hair-cloth for sacks and bags, and every description of saddlery and smith's work, as well as of mason's work and carpentry. Cook-shops and coffee-houses abound everywhere; and, during all the summer, there is an abundant supply of solid ice brought down from the summits of Mount Taurus, and sold at present for a farthing a pound. It is the seat of a considerable inland trade, being a thoroughfare for caravans passing from Aleppo into the interior of Persia. The population may be estimated at 50,000, amongst whom are 2000 Christians and 500 Jews, the rest being all Mahommedans. The Christians are chiefly Armenians and Syrians, each of whom have a separate church, and live in a separate quarter.

Orfa.

Orfa is of great antiquity, and is considered by all the learned Jews and Mahommedans, and by Christian scholars, as the Ur of the Chaldees. It was the Edessa of the Greeks and Romans, and was frequently taken and retaken during the wars between the Persians and Romans. In the reign of Heraclius, about A. D. 637, Orfa was taken by the Saracens, and its walls levelled with the dust. It was retaken by Baldwin in 1097, who founded the first principality of the Franks or Latins. It was also taken by Genghis Khan about the year 1144, and thirty years afterwards by

Orffyreus's Wheel || Organ.

Saladdin. It was sacked by the Moguls in the thirteenth century; and two centuries afterwards suffered the same calamity from the armies of Tamerlane. It was visited in 1544 by Tavernier, in 1738 by Pococke, who describes it as being in a flourishing state, and in 1766 by Niebuhr, who gives the same account of it. It is sixty-seven miles from Bir, and 232 from Diarbekir. Long. 38. 25. E. Lat. 36. 50. N.

ORFFYREUS'S WHEEL is a machine so called from its inventor, who asserted it to be a perpetual motion. This machine, according to the account given of it by s'Gravesande, in his *Œuvres Philosophiques*, consisted externally of a large circular wheel, or rather drum, twelve feet in diameter, and fourteen inches deep, being very light, as it was formed of an assemblage of deals, having the intervals between them covered with waxed cloth, to conceal the interior parts of it. The two extremities of an iron axis, on which it turned, rested on two supports. On giving a slight impulse to the wheel in either direction, its motion was gradually accelerated; so that after two or three revolutions it acquired so great a velocity as to make twenty-five or twenty-six turns in a minute. This rapid motion it actually preserved during the space of two months, in a chamber of the landgrave of Hesse, the door of which was kept locked, and sealed with the landgrave's own seal. At the end of that time, however, it was stopped, to prevent the wear of the materials. The professor, who had been an eye-witness of these circumstances, examined all the external parts of it, and was convinced that there could not be any communication between it and any neighbouring room. Orffyreus, however, was so incensed, or pretended to be so, that he broke the machine in pieces, and wrote upon the wall that it was the impertinent curiosity of Professor s'Gravesande which made him take this step.

ORFORD, a borough and market town of the county of Suffolk, and hundred of Plomsgate. It is a part of the parish of Sudborne, though separated from it, and stands at the confluence of the river Ore and Alde, ninety miles from London. Orford was a place of some trade till its harbour became chocked up. It has a mayor, recorder, twelve burgesses, and eight portmen, and returned two members to the House of Commons till 1832, when it was disfranchised. It is remarkable for the ruins of an ancient tower, which serves as a land-mark to vessels. It gives the title of baron to Earl Walpole. The population amounted in 1801 to 751, in 1811 to 737, in 1821 to 1119, and in 1831 to 1302.

ORGAL, amongst dyers, denotes the lees of wine dried.

ORGAN, in general, is an instrument or machine designed for the production of some certain action or operation; in which sense the mechanical powers, machines, and even the veins, arteries, nerves, muscles, and bones of the human body, may be called *organs*.

ORGAN, by far the most noble and imposing of all musical instruments. It is quite inconsistent with the design and limits of this work for us to enter into all the details of the nature and structure of the organ. They would fill a volume, and require many illustrative plates. We shall, however, endeavour to give such a general idea of the nature of the instrument as may satisfy those readers who are not professionally interested in the subject; and we assure them that their own inspection of the mechanism of an organ (which is easily attained in every large town) will afford them more clear and satisfactory knowledge than hundreds of pages written in explanation of its construction. For minute details, we refer to *L'Art du Facteur d'Orgues*, by F. Bedos de Celles, published at Paris in 1766 and 1778, in folio, with 137 plates. This is considered, even now, as the best and most complete work on organ-building. It is a pity we have none such in the English language. See also the Abbé Vogler's German works upon organ-building, and G. Serassi's *Lettere sugli Organi*, printed at Bergamo in 1816; together with Reports of the French Institute upon M. Grenié's improvements on the organ. We suspect that the general want of improvement in organ-building in Great Britain may be traced to the absence of such works, and some others, in our own language, for the instruction of our organ-builders. This may also explain, in some degree, why almost all the best organs in England were constructed by foreigners. Recently, however, we are happy to perceive a spirit of emulation arising amongst our native organ-builders; and we have little doubt that the ingenuity and superior workmanship of British artisans will soon enable us to vie with, or excel, the best organ-builders of the Continent. But, to do this, we must cast aside all national prejudices as to organs, &c. and meet foreigners upon a fair and liberal ground of competition.

Organ.

The earlier history of the organ is extremely obscure. A small and imperfect instrument, somewhat on the principle of the organ, may have been known to the ancients; but surely nothing like our great church-organ. We read of ancient *hydraulic* and *pneumatic* organs; but such distinction is so far erroneous, inasmuch as organ-pipes could not be made to sound by having *water* forced through them. The water must have been a moving power only, to impel the *wind* into the pipes. It would seem that the Greek and Latin terms ὄργανον and *organum*, translated by the English word *organ*, originally signified an instrument or machine of any kind, and were afterwards applied to musical instruments of all kinds. "*Organa dicuntur omnia instrumenta musicorum*," says St Augustin. Still later, according to St Isidore, these names, ὄργανον and *organum*, were applied to none but wind-instruments. In modern times the term organ, in a musical sense, came to signify only the instrument which we now know under that name. The passage in Eginhard's Annals which has been interpreted the sending of *an organ* by Constantine Copronymus to King Pepin in the year 757, may more probably mean "*various musical instruments*," since the words are, "*Constantinus Imperator Pipini regi multa misit munera, interque et organa*," &c. A writer of the sixteenth century has ventured to describe the supposed *organ* sent to King Pepin; and, by force of imagination, makes it out to have been a grand organ with pedals. In Luitprand's History (book vi. c. 2) there is a curious passage regarding an instrument sent to the Emperor Constantine in 950:— "Erat Regia ornata sumtuosissime, ibi ænea inaurata arbor ante ipsius imperatoris solium effulgebat, expansis magnum in modum ramis aereis atque inauratis; in his frequentissimæ variarum specierum aves arte confictæ, quarum singulæ speciei proprias voces cantusque emittebant, incredibili arte." In the second volume of Gerbert (*De Cantu et Musica Sacra*, plate xxviii.) will be found a representation of a tree of this kind with birds upon it. The Chronicle of Albericus adds to the singing of the birds before Constantine, "the roaring of enormous gilded artificial lions." (See Gerbert, vol. ii. p. 151.) That such birds can be made, is certain from Maillardet's beautiful little artificial bird, which started up out of a gold snuff-box, fluttered its wings, and sang with a pipe so clear and loud as to fill a large room. It would appear that, in the rude instruments called organs in the eleventh and twelfth centuries, the pipes were disposed in such a manner that every sound in its finger-key compass caused the fifth and the octave of that sound to be heard above it. Such a succession of fifths and octaves was called "organum," no doubt *par excellence*. From this and the old and extraordinary specimens of *Biscantus*, or *Discantus*, given by Gerbert and others, and alluded to in our article MUSIC (page 623), we are inclined to believe that the modern mixture-stops of the organ have originated. We leave the consi-

Organ. deration of the ancient organs to antiquaries, and now proceed to the modern organ, which seems to have assumed something of its present form in the fifteenth century.

The mechanism of the modern organ has been much improved at different times by different builders. The family of the Antegnati, of Brescia, were amongst the earliest famous organ-builders in Italy in the fifteenth and sixteenth centuries. In the eighteenth century there were in Italy many celebrated organ-builders, amongst whom Serassi of Bergamo, and Callido of Venice, each constructed upwards of three hundred organs.

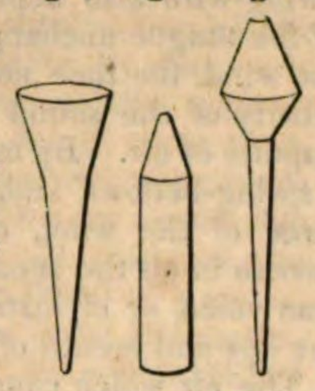
Most of our readers probably know already that the great organ is a complex wind-instrument, consisting of a great number of pipes of different sizes, formed of wood and of different kinds of metal, some of which are flute-pipes or mouth-pipes, and others reed-pipes; whilst all of these are made to sound by means of compressed air applied to them through certain channels, by bellows worked either by human force or by mechanism. There are different kinds of organs, from the Lilliputian bird-organ up to the great church-organ. We pass over the minor ones, including the chamber-organs and the smaller chapel-organs, and proceed to the great church-organ. We need not describe its front, nor the case in which its mechanism is contained. The great church-organ has usually three rows of finger-keys, placed above each other like steps. In some of the largest organs there are four, or even five such rows of keys. Besides these, there are rows of pedals, or foot-keys, which act upon the larger pipes of the organ. The bellows communicate, by a wind-trunk, with wind-chests, or reservoirs of air, whence the wind is distributed to the various pipes of the organ when the finger-keys or the foot-keys (pedals) are pressed down. Attached to the upper part of each wind-chest is a sound-board, as it is rather improperly called. This sound-board consists of two parts, an upper and an under board, the latter of which is much thicker than the other. Both of these are formed of planks of wood laid horizontally side by side, and accurately joined together at their edges. In the under side of the lower board several rectangular grooves or channels are cut parallel to each other, and carried along nearly the whole length of the board, and as far as there are stops in the organ. In these channels are fixed bars of wood, so as to render each channel or *partition* completely separate from every other. In the upper side of this board are cut a number of other rectangular channels or grooves running across the board, and at right angles with the under grooves. Into these upper grooves are exactly fitted wooden sliders, or registers, which run the whole length of the grooves. These sliders can be drawn out so far or pushed in at pleasure, by a mechanism attached to the draw-stops that are placed on the right and left in front of the organ. Holes corresponding with the number or rows of organ-pipes placed above the sound-board, are pierced through the latter into the above-mentioned channels, and also through the sliders or registers, in such a manner that when the latter are drawn out, their holes correspond with those of the sound-board, and allow the air from the wind-chest to pass through them and through the other holes in the sound-board; whilst, on the contrary, when the sliders are pushed in, they completely prevent any air from passing from the wind-chest to the pipes above the sound-board. Above all, and corresponding with the upper holes of the sound-board, are placed the pipes, fitted in by their conical feet to what are called the stock-boards. There are rows of thin boards, called racks, which are sustained by pillars of wood, and which receive the upper part of the feet of the pipes in holes made for the purpose. Opening into the wind-chest, and fixed upon the under side of the sound-board, are spring-valves, which are connected, by a particular mechanism, with the finger-keys and pedals; and which, when the sliders are drawn out, and the keys and pedals pressed down, are made to open, and so to admit the air from the wind-chest into the channels or partitions belonging to the different rows of pipes constituting the various stops of the organ. The pedals and the finger-keys communicate with these spring-valves by means of an apparatus of trackers, cranks, and rollers, acting upon pull-down wires that pass through the bottom of the wind-chest, and are attached to these valves. The draw-stop movement, by which the sliders are drawn out or pushed in, consists of a similar mechanism. In some organs these sliders are superseded by another contrivance. Thus, in what are called by the Italians *somieri a vento*, the opening of a given stop or register is not effected by drawing out a wooden slider, so as to make its apertures correspond with those in the sound-board; but by pulling open, all at once, in the channels of the sound-board, as many small valves as there are pipes to that given stop. These small valves are made to open by pulling out a draw-stop, and to shut by pushing it in again. They are considered to have many advantages over the ordinary slider, as being more durable, and less subject to the influence of changes of the weather. Organ.

A stop is called simple if it consists of one row of pipes, and compound if it consists of more than one row. As to the different rows of finger-keys, each communicates with what is really a separate organ, or collection of pipes, with its peculiar wind-trunk, wind-chest, sound-board, &c. These different organs are generally three, and are called the great organ, the choir-organ, and the swell-organ. The middle row of keys is connected with the great organ, the lower with the choir-organ, and the upper with the swell-organ. The swell-organ has its pipes enclosed in a wooden box furnished with a sliding door, or a hinged door, which is gradually opened or shut by mechanism moved by the performer's foot applied to a pedal. All these different organs, constituting the great church-organ, are supplied with air by the same bellows, and by suitable wind-trunks connected with the bellows. The bellows now generally used are horizontal ones, instead of the old ones resembling blacksmiths' bellows. For some improvements in the sound-board and its appurtenances, see Serassi's *Lettere sugli Organi*.

We have already mentioned, that the pipes of an organ generally consist of mouth-pipes and of reed-pipes. With regard to the mouth-pipes, their nature may be pretty well understood by any one acquainted with the upper part of the common English flute, or the flageolet. The reed-pipes are explained in a subsequent part of this article. What we have said regarding sonorous tubes in the article Music, pages 608, 613, 615, may assist the reader in understanding our notices of organ-pipes. Organ-pipes are either open, or stopped, or half-stopped. The stopped ones have a plug or tompion inserted into their upper end, and pushed down or pulled up to regulate the pitch. The half-stopped ones have a kind of chimney at the top. Some of the middle-sized ones are partly stopped, and have also on each side of the mouth a kind of ear of metal, by bending of which outwards or inwards, the pitch of the pipe may be regulated. The largest pipes are square ones of wood, and belong to the pedals. In some great organs, the largest open pipe is thirty-two feet in length. The other pipes are made of wood or of metal. It has been observed by organ-builders and others, that the quality of tone (*timbre*) of pipes depends much upon their proportions in length and width, the material of which they are made, &c.; and also upon the form of their open top, by which the wind escapes. We shall have occasion to notice this again, when describing some of Grenié's improvements. A reed-pipe, with a conical tube which has a bell-shaped end, as in fig. 1, gives the most brilliant sound. If the pipe

Organ. have a reversed conical top, as in fig. 2, the sound becomes dull. If two similar truncated cones placed base to base be fixed to the wider end of a long conical tube, as in fig. 3, a reed-pipe so formed will give fulness and strength to the sound. Theory affords no satisfactory explanation of these facts. The *timbre* of the stopped and of the half-stopped pipes is softer and duller than that of the open ones. Pipes of pure tin have long been known to possess a *timbre* more clear and penetrating than those made of tin mixed with lead. Some years ago, a Bohemian organ-builder made some of his pipes of zinc, which was said to answer better than even tin. No doubt various simple and compound metals, and various other substances that have not yet been used in the making of organ-pipes, might be employed with advantage to produce a still greater variety of *timbres* and effects; and for the same purpose, various modifications of the ordinary forms of pipes might also be employed.

Fig. 1. Fig. 2. Fig. 3.



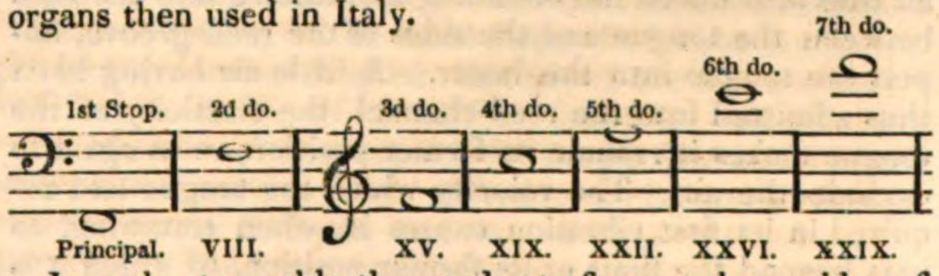
The pipes and stops of an organ differ in number and kind according to the size of the organ, the fancy of the builder, and the taste of the public. In some Dutch, German, and Italian organs, there seems to be a superfluity of stops. An immense organ at Weingarten, in Germany, is described as having sixty-six stops and 6666 pipes. The great organ at Haarlem contains sixty stops, and its largest pipe is thirty-two feet in length. For an enumeration of the stops of three of Silbermann's organs at Dresden, we refer to a Ramble among the Musicians of Germany, published at London in 1828 (pp. 193, 194, 195). One of the largest organs in Italy is said to be that built in 1733, by Azzolino della Ciaja, for the church of the Cavalieri di S. Stefano at Pisa. It is said to have four rows of finger-keys, and more than 100 stops. Another remarkable one is in the church of S. Alessandro in Colonna, at Bergamo. It was built by Serassi in 1782, and has three rows of finger-keys, and about 100 stops. In it the first and second rows of keys serve for the great organ, and the second organ or choir-organ, built together in the same part of the church. The third row of keys is connected, with mechanism which passes under ground and extends to a distance of about 115 feet English, with a third great organ placed in another part of the church, and directly opposite to the first. Notwithstanding such a distance from the keys, the third organ obeys them as readily as the first one does. Its lowest pedal-pipes consist not only of mouth-pipes, but also of reed-pipes. The following is a brief description of another organ built by Serassi in 1796. "Two rows of finger-keys, the upper for the great organ, the *ripieno* of which consists of the following stops: Two principal soprani; two principal basses; octave, twelfth, fifteenth, twenty-second, twenty-sixth, twenty-ninth, two thirty-thirds, two thirty-sixths, and twelve deep bass stops belonging to the chromatic scale, with the octaves of these, all, however, governed by one register. The different stops belonging to the great organ are, the sesquialtera; two cornets; flute in octave; flute in twelfth; German-flute; vox humana; viola; bassoon; English horn; trumpets; trombones; cymbals; kettle-drums, and bass-drum, the last being managed by a pedal. The lower row of manuals or finger-keys serves for the second organ, or choir-organ. It has its *ripieno*, composed of principal, octave, fifteenth, nineteenth, twenty-second, twenty-sixth, and twenty-ninth; and has, besides, the stops of cornet, flute in octave, vox humana, and violoncello. By means of a pedal moved by the right foot, all the stops of the first organ can be opened or shut at once."

Of the different stops or registers of an organ, some derive their names from the instrument the tone of which they imitate, and some from the relation in pitch which they bear to the sounds of the diapason stop, as octave, twelfth, fifteenth, seventeenth, and so on. We subjoin a brief account of the most usual organ-stops. I. *Open diapason;* consists of metal mouth-pipes open at the upper end, and extends through the whole scale of the organ, as its name diapason imports. II. *Stopped diapason;* mouth-pipes generally of wood, and their pitch an octave below that of the open diapason. They are stopped at the upper end. III. *Double diapason;* wooden mouth-pipes, open at the upper end, and their pitch an octave lower than those of the open diapason. They are generally confined to the two lowest octaves of the organ's compass. In some of the largest organs, the gravest sound of these is rendered by an open pipe thirty-two feet in length. IV. *Principal;* metal mouth-pipes, the pitch of which is an octave above the open diapason. The *principal* is the first stop tuned; and then, from it, all the other stops. V. *Dulciana;* a metal mouth-pipe stop, tuned in unison with the open diapason. The sweetness of its tone originates in the length and narrowness of its pipes. VI. *Twelfth;* metal mouth-pipes tuned a twelfth above the open diapason. VII. *Fifteenth;* metal mouth-pipes tuned an octave above the principal. There are, in some organs, stops named *tierce* or *seventeenth*, *larigot* or *nineteenth*, *twenty-second*, *twenty-sixth*, *twenty-ninth*, *thirty-third*, &c., tuned respectively at these intervals above the open diapason. VIII. *Flute;* metal and wood mouth-pipes, in unison with the *principal*. IX. *Trumpet;* reed-pipes of metal, in unison with the open diapason. X. *Clarion* or octave trumpet-stop; metal reed-pipes tuned an octave higher than those of the trumpet stop. XI. *Bassoon;* reed-pipes, in unison, as far as their compass reaches, with pipes of the open diapason. XII. *Cremona*, or properly *krum-horn;* reed-pipes, in unison with the open diapason. XIII. *Oboe;* reed-pipes, in unison with the open diapason. XIV. *Vox humana;* reed-pipes, in unison with the open diapason, and intended to imitate the human voice, a function which in general they perform very unpleasingly.

Organ.

Amongst the *compound* stops used in organs are, I. The *sesquialtera*, consisting of four or five rows of open mouth-pipes at the intervals of seventeenth, nineteenth, twenty-second, twenty-fourth, or twenty-sixth, above the open diapason. II. The *cornet*, a stopped diapason, principal, twelfth, fifteenth, and seventeenth. III. *Mixture* or *furniture* stop, consists of several ranks of pipes nearly the same as those of the sesquialtera, but some of them of a higher pitch. Vogler denounces the *mixture-stops* as "*insignificant.*" We have sometimes heard a harsher term applied to them.

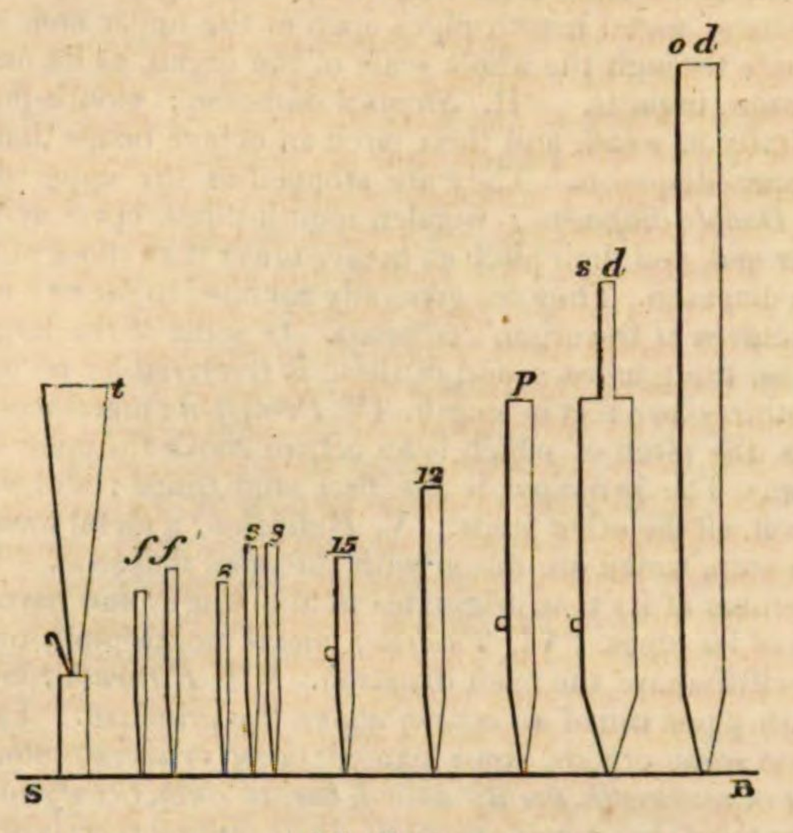
In Costanzo Antegnati's *Arte Organica* we find the following exposition of the series of registers or stops of the organs then used in Italy.



In order to enable the reader to form a clearer idea of the distribution of the pipes of an organ, we subjoin a sketch of a row of the usual pipes of the great organ (as contradistinguished from the choir and swell organs), and as these pipes stand upon and are inserted in the top of the sound-board. To simplify the diagram, the rack-board and pillars are not represented here. The letter *t* indicates the trumpet; *ff*, furniture; *sss*, sesquialter; 15, fifteenth; 12, twelfth; *p*, principal; *sd*, stopped diapason; *od*, open diapason; SB, the top of the sound-board. The other rows of pipes are, of course, to be imagined as placed behind those pipes here represented, and as extending, in their respective ranks, the whole length of each stop

Organ. or register, in lines at right angles with the line formed by the row of pipes shown in the diagram.

Fig. 4.



Not many years ago, M. Grenié, a French amateur of music, introduced several important improvements in the construction of reeds for organ-pipes. (See the Reports of the French Institute, &c.) His reed (AB in the annexed figure 5) was made of wood or copper, square-edged, and of the form of a parallelopipedon. [In order to show the difference between the construction of M. Grenié's reed and the common organ-pipe reed, we add a diagram of the latter, fig. 6.] The tongue was a thin plate of brass, of an even surface, and cut in a rectangular shape, so as to fit almost exactly the grooved face of the reed. A strong wire-spring *cc* kept down this tongue firmly upon the reed, at the proper length, so as to regulate the tongue's vibrations. The result of such a construction is, that when this reed, enclosed in its tube, is made to sound by air forced into the porte-vent DEF, by the aperture at F, the air thus introduced not obtaining admittance into the reed between the tongue and the sides of the reed-groove, impels the tongue into the latter. A little air having been thus admitted into the reed-channel, the elasticity of the tongue makes it resume its former position, so as again to exclude the air. The velocity which the tongue had acquired in its first vibration causes it, when returning, to pass beyond the limit of its former position, to which it is again brought back by the resistance of the air, and by its own elasticity, and whence the impulse of the current of air from the porte-vent again forces it into the reed-channel. The advantages of this construction are, that the tongue does not strike against the edges of the reed, as in the common reed-pipes, which thereby produce a harsh and uneven tone; and that its movements are smooth and regular, since it has nothing to encounter in its vibrations but the air itself. The sound of M. Grenié's reed-pipes is said to be, in the most acute as well as in the gravest of them, as sweet and pure as that of flute-pipes. M. Grenié adapted the degree of strength and rigidity of each tongue to the breadth of the reed-channel which it had to cover, so that the stream of air could never throw it into vibrations around its axis. The strength of the spring-wire also kept the length of the vibrating portion of the tongue unchanged; so that, whatever the force of the wind, the tone never altered its pitch. Only the intensity of the sound was affected by the greater or less impulse of air. By means of a pedal, the performer moved a spring-bellows, and, by thus regulating at pleasure the force of the wind, could obtain a *crescendo* and *diminuendo* in all the reed-pipes, as perfect as that of the human voice, or of instruments modified in their sounds by the lips and breath of the performer.

Organ.

Fig. 5.

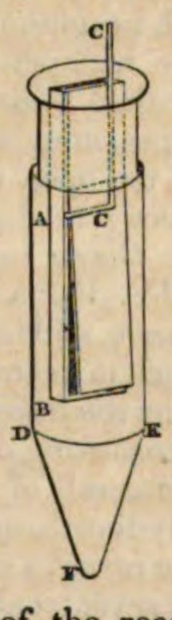
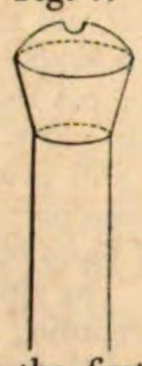


Fig. 6.

The air which causes these reeds to vibrate passes out through open pipes, bevelled off into a cone, and terminating in a hemisphere, fig. 7. This form is said to give roundness and strength to the tone.

Fig. 7.



M. Grenié, when constructing his reed-pipes, was for a long time checked by a very curious phenomenon. He was at first occupied with the gravest octave of which the sound C is in unison with an open flute-pipe of eight feet; and had constructed a certain number of pipes, in giving wind to all his reeds by pipes of the same length, fig. 8. But when he had reached the first notes of the tenor compass, still continuing to construct his porte-vents in the same manner, the reed would not sound at all. He in vain increased and diminished the wind, in vain lengthened and shortened the tongue; the reed remained mute, or produced only very bad sounds. At last, after many attempts, M. Grenié thought that the length of the pipe which conducts the wind to the reed might have some unknown influence upon its vibration. He therefore substituted for his fixed tubes two pipes, of which the one was made to slide within the other, so that he could gradually vary the whole length. He tried this change of length until the reed produced a clear, pure, and sustained sound. He found also, that in order to obtain the tenor sounds in all their fulness, it was necessary to make the porte-vent much longer than for the sound immediately preceding, and this length always went on diminishing for the most acute octaves, as is represented by fig. 9. Then the tops

Fig. 8.

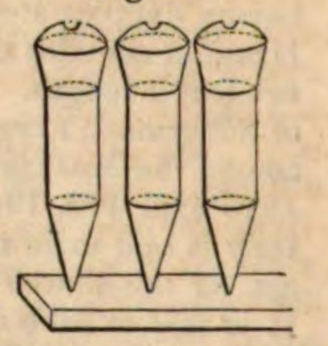
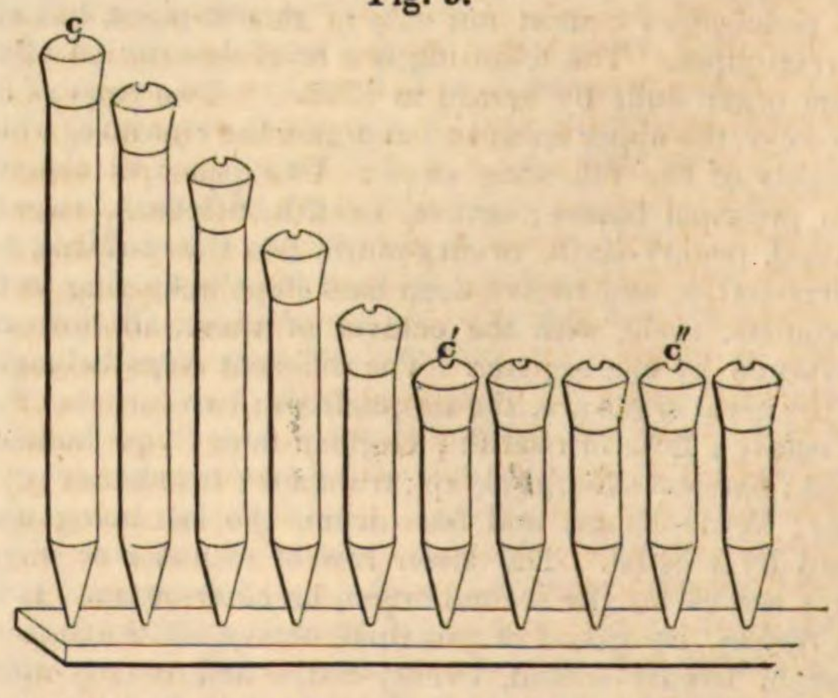


Fig. 9.



of the pipes formed the curve C C′ C″. This seemed to indicate that, by prolonging that curve, one would obtain the most favourable dimensions for those pipes of the first octave which M. Grenié had at first made of equal lengths. But, to his great surprise, he found that there

Organ. was no advantage whatever in doing so; but that, on the contrary, the sounds became very dull and irregular. He therefore reasonably adhered to his first construction, which, nevertheless, he still purposed to improve, by afterwards making all his porte-vents sliding tubes, so that each of them might have the most favourable length given to it. He has since constructed, on this same model, open reed-pipes of sixteen feet, which sound with very remarkable distinctness, strength, and regularity. In this case the tongue is a flat slip of copper, in length 0·240 of a metre, in breadth 0·035 of a metre, in thickness 0·003 of a metre; equal respectively to 9·449040, and 1·377985, and 0·118113 English inches and decimal parts. Its vibrations are so powerful, that they cause the pipe in which it is placed, the porte-vent over which it is mounted, and all neighbouring elastic bodies, to tremble. Of course, in order to make it sound, a powerful and well-managed bellows-force is necessary. That which M. Grenié employed was perfect in regularity and power. It had a double current of air, and was worked by one handle. M. Grenié obtained a patent for his improvements. He considered the mixture-stops in common organs as productive of nothing but bad effects, and therefore excluded them from his organ. (See report by Cherubini, Catel, Baillot, &c. in 1811.) We have given so full an account of Grenié's improvements, in order to excite the attention of British organ-builders to this subject, and induce them to discover many more improvements of which our organs are unquestionably susceptible.

One of the greatest steps to improvement in English organ-building was made upwards of twenty years ago, by Messrs Flight and Robson of London, in the construction of their magnificent organ, called the Apollonicon. It was exhibited to the public, and attracted vast numbers of visitors. The ingenuity of its mechanism, the excellence of its workmanship, the fineness of its tone, and the novelty and grandeur of its effects, were universally acknowledged. This fine instrument was played either by means of the revolutions of three large cylinders, or else by means of six different sets of finger-keys acted upon simultaneously by six different performers. The Apollonicon was about twenty-four feet high and twenty broad. We heard it in 1817, and were much struck by its varied and powerful effects. However, the room in which it was placed was neither sufficiently large, nor so proportioned in form, as to display the powers of this organ to the best advantage. This fine instrument alone is sufficient to bear us out in what we have said at the beginning of this article, as to the certainty of English organ-builders being able to rival, or to excel, the foreign ones, if they choose to exert themselves.

Several methods have been proposed in England to render the intonation of the organ less imperfect, by dividing the octave into a greater number of intervals than the usual twelve: amongst others, that employed in Hawke's patent organ, described in the thirty-sixth and thirty-ninth volumes of the Philosophical Magazine. Hawke divided the octave into seventeen intervals. Loeschman's patent organ was another of this kind. He divided the octave into twenty-four intervals, which were produced by six pedals and twelve finger-keys. (See description in vols. xxxvii. xxxviii. of Philosophical Magazine.) In 1810, the Rev. Henry Liston, a clever and ingenious Scottish clergyman, obtained a patent for an instrument, constructed by Messrs Flight and Robson, which he named the *Euharmonic Organ*. (See vol. xxxvii. of Philosophical Magazine.) Another organ, similar to the one last mentioned, was made for Mr Liston by the same builders. (See Philosophical Magazine, vol. xxxix.) It had eleven pedals, six of which were the same as those in Loeschman's organ. In the second organ built for Mr Liston, there was a contrivance for an occasional alteration of the pitch of the pipes, in the requisite degree, by means of flat metallic plates, which, when acted upon by the pedals, were brought, at due distances, over the tops of the open pipes, or opposite to the mouths of the stopped pipes, so as to flatten the pitch when this change was required. Organist ‖ Organo-Lyricon.

The object of Mr Liston's organ was to supersede temperament; but although its ingenuity and its effects were admired by many of the best musicians in London, the complexity of its manuals and pedals prevented it from ever being generally adopted. And this has been the fate of all such instruments, in modern as well as in ancient times; for attempts of a similar kind were made, centuries ago, to introduce such minute subdivisions of the octave into keyed instruments. The Spanish writer Salinas, in his work *De Musica* (lib. iii. c. 27), speaks disparagingly of an instrument called an Archicymbalum, which had been constructed in Italy above forty years before the publication of his work in 1577, and in which every tone was divided into five parts. "Non silentio prætermittendum arbitror instrumentum quoddam, quod in Italia, citra quadraginta annos fabricari cœptum est, ab ejus autore, quisquis ille fuit, Archicymbalum appellatum. In quo reperiuntur omnes toni in quinque partes divisi: ex quibus tres vindicat sibi semitonium majus, et duas semitonium minus, a quibusdam magni nominis musicis in pretio habitum, et usu receptum: eo quod omnis in eo sonus habet omnia intervalla, atque omnes consonantias (ut sibi videntur) inferne, et superne, et post certam periodum ad eundem, aut equivalentem sibi sonum post 31 intervalla reditur," &c. In the latter part of the last century, F. X. Richter, chapel-master in the cathedral of Strasburg, usually composed upon a clavichord, which had twenty-one sounds to the octave, and which then seemed to be upwards of two hundred years old. Richter died in 1789, aged eighty.

For some hints regarding the proper use of the organ, see the article Music (vol. xv. p. 644). Those who wish to extend their knowledge of this subject will find abundance of information upon the history and the construction of the organ, and the art of playing it, in works published in Germany, France, and Italy. The German works are the most numerous. (G. F. G.)

ORGANIST, a person who plays upon the organ. In Germany and Prussia, the requisites of a good organist are so many in point of musical education, and musical taste, and mechanical skill, that hardly any of the organists of other countries would venture to enter into competition with the German or Prussian organists. All the best works upon the art of organ-playing are in the German language. We may cite, as one of these, Rink's work upon organ-playing.

ORGANO-LYRICON, a musical instrument invented at Paris in 1810, by M. de Saint Pern. Its height is about eight feet two inches English, its breadth six feet six and a half inches, its depth about four feet four inches. It consists of a piano-forte, coupled with twelve different wind-instruments, viz. three kinds of flutes, an oboe, a clarinet, a bassoon, horns, trumpet, and fife. It has two rows of finger-keys. The lower row belongs to the piano-forte; but, by an ingenious mechanism, and according to the depression of the keys by the performer, it may be made to sound either the piano-forte alone, or a flute, or an oboe, or to unite them all. The upper row of finger-keys has no action on the piano-forte; but, by management of the pressure, it causes the German flute or the oboe to sound, and produces *rinforzi* by the gradual re-union of several wind-instruments. Independently of these functions, this row of finger-keys is destined for a great church-organ placed above it. The correspondence between the two rows of finger-keys is such, that they may, at the will of the performer, act together or separately, or even partially. The finger-keys are singularly light in their touch, even at their maximum of depression. At the bottom of

Orgia || Orichalcum.

the instrument there are pedals for the double bass, and for other combinations. The wind-chests are numerous, and of such capacity that the wind of the large bellows which fill them cannot produce in them any augmentation injurious to the purity of the *timbre* and the trueness of the intonation. In this instrument, by means of ingenious contrivances, the inconveniences of an irregular supply of wind have been carefully avoided. A double pedal for the right foot enables the performer to work the bellows himself when he is alone. An adjacent pedal, turned the opposite way, enables an assistant to do this. But, to avoid the trouble of these pedals, M. de Saint Pern placed in an adjoining room a large piece of clock-work, moved by a weight of fifty pounds, which served instead of a bellows-blower. The performer has beside him a mechanism that communicates with the clock-work, and, by means of a click and spring, leaves the weight going, or stops it at pleasure. See Report read to the French Institute on the 10th of September 1810; also Report of the French Conservatory of Music, 12th of August 1810, where it is said that "M. de Saint Pern's organo-lyricon might, in a large room or a chapel, hold the place of an orchestra, and imitate nearly all the effects of one."

ORGIA, feasts and sacrifices in honour of Bacchus, which were held every third year, and chiefly celebrated by wild, distracted women, called *Bacchæ*. The chief solemnities were performed in the night, to conceal, perhaps, their shocking impurities; and a mountain was generally chosen as the place of celebration. They were instituted by Orpheus, and from him are sometimes called *Orphica*. Authors are not agreed as to the derivation of the word; but if we consider the frantic proceedings of the Bacchanalians, ὀργη, *furor*, bids fair for being the true etymology.

Orgia, according to Servius, was a common name for all kinds of sacrifices amongst the Greeks, as *ceremoniæ* was amongst the Romans.

ORGUES, in the military art, are thick long pieces of wood, pointed at one end, and shod with iron, which being kept clear one of another, hang each by a particular rope or cord, perpendicularly, over the gateway of a strong place, to be let fall in case of the approach of an enemy.

ORGUES is also used for a machine composed of several harquebuss or musket barrels bound together, by means of which several explosions are made at the same time. It is used to defend breaches and other places attacked.

ORGYA, ὀργυια, an ancient Grecian measure containing about six English feet.

ORIBASUS, a celebrated physician, greatly esteemed by the Emperor Julian, in whose reign he flourished. At the request of the emperor, he abridged the works of Galen, and of all the most respectable writers on physic; and he accompanied Julian into the East, but his skill proved ineffectual in the attempt to cure the fatal wound which his benefactor had received. After Julian's death he fell into the hands of the barbarians.

ORICHALCUM, or AURICHALCUM, a metallic substance resembling gold in colour, but very inferior in value. It was well known to the Romans, who often took advantage of its resemblance to gold; for some sacrilegious characters, who could not resist the temptation of taking gold from temples and other public places, chose to conceal their guilt by replacing it with orichalcum. It was thus that Julius Cæsar acted when he robbed the capitol of three thousand pounds weight of gold; in which he was followed by Vitellius, who despoiled the temples of their gifts and ornaments, and replaced them with this inferior metal. It has been a matter of dispute with philosophers and others, what the composition of this metal could be, or how it was procured; it is probable, at least, that it was analogous to our brass, if not wholly the same with it.

The Romans were not only in possession of a metallic substance, called by them *orichalcum*, and resembling gold in colour, but they knew also the manner of making it; and the materials from which they made it were the very same with those from which we make brass. There are, indeed, authors of great repute who think very differently, and consider the art of making brass as an invention wholly modern. Thus M. Cronstedt does not think it just to conclude from old coins and other antiquities, that the making of brass was known in the most ancient times; and the authors of the French *Encyclopédie* assure us that our brass is a very recent invention. It appears, however, from Pliny (*Nat. Hist.* lib. xxxiv. § 2), and from the concurring testimony of other writers, that *orichalcum* was not a pure or original metal; but that its basis was copper, which the Romans changed into *orichalcum* by means of *cadmia*, a species of earth which they threw upon the copper, and which it absorbed. It has indeed been contended that the *cadmia* of Pliny was native arsenic; an opinion which scarcely merits confutation, but which must appear extremely groundless, when we reflect that it is impossible to make either brass or copper from arsenic, and that Pliny expressly calls the substance from which brass was made a *stone*. The testimony of Ambrose bishop of Milan in the fourth century, and of Primasius bishop of Adrumetum, in Africa, in the sixth, and of Isidorus bishop of Seville in the seventh, all seem to confirm Pliny's account. We may therefore safely conclude, that the Romans knew the method of making brass by mixing *cadmia* or *calamine* with copper. Yet it is probable they were not the inventors of this art, but borrowed it from some other country. It appears from a variety of testimonies that brass was made in Asia, in a manner similar to that employed at Rome; and a variety of places are mentioned where it was commonly made. It is supposed by some that in India, as well as in other parts of Asia, it was made in the remotest ages.

Orichalcum.

With respect to *orichalcum*, it is generally supposed that there were two sorts of this metal, one factitious, and the other natural. The factitious, whether we consider its qualities or its composition, appears to have been the same with our brass. As to the natural *orichalcum*, there is no impossibility in supposing that copper ore may have been so intimately blended with an ore of zinc, or of some other metallic substance, that the compound, when smelted, might yield a mixed metal of a paler hue than copper, and resembling the colour of gold or of silver.

We know of no country in which *orichalcum* is found at present; nor was it anywhere found in the age of Pliny, who does not seem to have known the country where it had ever been obtained. He admits, indeed, that it had been formerly dug out of the earth; but it is remarkable, that in the very passage where he mentions by name the countries most celebrated for the production of different kinds of copper, he only says in general, concerning *orichalcum*, that it had been found in other countries, but without specifying any particular country. Plato acknowledges that *orichalcum* was a thing only talked of even in his time; it was then nowhere to be met with, although in the island of Atlantis it had been formerly extracted from the mine. The Greeks were in possession of a metallic substance called *orichalcum* before the foundation of Rome. It is mentioned by Homer and by Hesiod, and by both of these poets in such a manner as shows that it was then held in great esteem. Other ancient writers have expressed themselves in similar terms of commendation; and it is principally from the circumstance of the high reputed value of *orichalcum* that authors have been induced to suppose that the ancient metal of this name was a natural substance, very different from the factitious one in use at Rome, and probably in Asia, and which, it has been shown, was in no respect different from our brass.

But this conclusion cannot be validly deduced from their

Orient, L' || Origen.

encomiums upon *orichalcum;* for, at whatever time the method of making it was first discovered, its novelty and scarcity, joined to its utility, would enhance its value; at least there can be no absurdity in supposing, that when first introduced it was greatly prized, even though it be granted that it possessed no other properties than such as appertain to brass.

With respect to the etymology of the word there exists great diversity of opinions. Those who write it *aurichalcum* think it is composed of the Latin word *aurum*, gold, and the Greek χαλκος, *brass* or *copper*. But the most general opinion is that it is composed of ὀρος, *a mountain*, and χαλκος, *brass*, alluding perhaps to its being found in mountains or mountainous countries.

ORIENT, L', an arrondissement of the department of Morbihan, in France, which extends over 741 square miles. It comprehends eleven cantons, divided into forty-eight communes, and in 1836 it contained 133,307 inhabitants. The capital is the city of the same name. It is a fortified seaport, and a royal naval arsensal, standing at the mouth of the river Scorf, where it enters the bay of Port Louis. There are all those establishments for the building and equipping of ships of war. It is a well-built place, with long straight streets, and very fine quays. It has three churches, a naval hospital, 2000 houses, and 18,975 inhabitants. It is considerable also as a commercial port, is a dépôt for East India commodities, and has a great trade to the West Indies and the north of Europe. Long. 3. 30. W. Lat. 47. 48. 11. N.

ORIGEN, a celebrated ecclesiastical writer, and one of the greatest geniuses, as well as most learned men, of the church, during the third century, was born at Alexandria in the year 185. He was surnamed *Adamantius*, either from his indefatigable application to study, or from the firmness he discovered amidst the torments which he suffered for the faith. Leonidas, his father, trained him with great care, and caused him, from his infancy, to apply to the study of the Scriptures, in which he made surprising progress. The son's inclination and turn of mind suited exactly with the father's design; for he pursued his studies with extraordinary zeal and ardour; and, being endowed with a quick apprehension and a strong imagination, he did not content himself with that sense which at first presented itself, but endeavoured to discover mysterious and allegorical explications of the sacred books. He would sometimes even puzzle his father, by soliciting the latter for recondite meanings; which obliged the good man to reprehend him a little, and withal to advise him not to attempt to penetrate too far in the study of the Scriptures, but to content himself with their clear, obvious, and natural sense. Hence it appears how early he was seized with that *furor allegoricus*, as a learned modern calls it, that rage of expounding the Scriptures allegorically, which afterwards became a distemper, and carried him to excesses which can never be excused. In philosophy he had the celebrated Ammonius as his teacher, and St Clement of Alexandria for his master in divinity. At eighteen years of age he succeeded the latter in the office of catechist; an important employment, which consisted in teaching divinity, and in expounding the Scriptures. Leonidas his father had suffered martyrdom the year before, during the persecution of Severus, in 202; and Origen had shown such eagerness to follow his father to martyrdom, that his mother was obliged to hide his clothes to prevent him going abroad. Origen had a great concourse of auditors who attended his school, some of whom were of the faithful, and the others Pagans. He confirmed and strengthened the former in their faith, and converted most of the latter; and there were such a number of martyrs amongst his disciples, that it might be said that he kept a school of martyrdom rather than one of divinity. He taught the doctrines of Christianity to the women and girls, as well as to the men; and taking in a too literal sense what Christ says of becoming voluntary eunuchs, castrated himself, to prevent his deserving or suffering scandal. He took a voyage to Rome in 211, in the beginning of the reign of Caracalla, under the pontificate of Zepherinus. On his return he published many works, whereby he acquired an extraordinary reputation, which drew to him a great number of auditors. But Demetrius, bishop of Alexandria, conceiving a jealousy of him, endeavoured upon various pretences to injure him. At length Origen went to Antioch, whither the Empress Mammæa had sent for him to hear him discourse on the Christian religion. He did not however stay long there, but returned to Alexandria, where he continued to teach till the year 228, when he left that city and travelled into Achaia. He then went into Palestine, and was ordained by the bishops of that province at forty-two years of age. But the circumstance of his being ordained by foreign bishops, without the permission of Demetrius, renewed that prelate's resentment against him; upon which Origen hastily returned to Alexandria, to endeavour to mollify him. Demetrius, however, drove him thence in the year 231, and caused him to be excommunicated, and even deposed, in a council which was held in Egypt. Origen then retired to Cæsarea in Palestine, where he raised a celebrated school, and had St Gregory Thaumaturgus, and a great number of other persons who were illustrious for their virtue and learning, as his disciples. He afterwards travelled to Athens, and, at the desire of Firmilianus, staid some time at Cæsarea in Cappadocia; whence he was invited into Arabia, to convince and bring back to the truth Beryllus bishop of Bostra, who maintained that the Word had no existence before his incarnation. Origen had the happiness to make him sensible of his mistake; and some years afterwards he was sent into Arabia by an assembly of bishops, to dispute against certain persons who maintained that the souls of the dead remained in a state of insensibility till the general resurrection. At length the seventh persecution of the Christians began in the reign of Decius, and none was treated with greater severity than Origen. He supported with incredible constancy the dreadful torments which the persecutors of the Christians invented against them; torments which were the more insupportable, as they were made to continue for a long time, and as the persecutors took the greatest care to prevent his expiring in the midst of his tortures. But in the most excruciating agony he discovered an heroic courage, and suffered nothing to escape him which was unworthy a disciple of Jesus Christ. Origen died at Tyre in the year 254, aged sixty-nine. He was the author of a great number of excellent works. The principal of those which have descended to us are, 1. A Treatise against Celsus, of which a good edition in Greek and Latin, with notes, has been published by Spencer; 2. A number of Homilies, with Commentaries on the Holy Scriptures; 3. Philocalia, and several other treatises; 4. Fragments of his Hexapla, collected by Montfaucon, in two volumes folio. Of all Origen's works, the loss of the Hexapla is most to be regretted. This work was thus named from its containing six columns, in the first of which was the Hebrew text of the Bible; in the second, the same text in Greek characters; in the third, the Greek version of the Septuagint; in the fourth, that of Aquila; in the fifth, that of Symmachus; and in the sixth, Theodosian's Greek version. This admirable work first suggested the idea of our Polyglot Bibles. Of the book of Principles we have only an incorrect Latin version. The most complete edition of the works of Origen is that of Father Delarue, a Benedictine, in Greek and Latin. Montfaucon likewise published, in two volumes folio, some remains and fragments of his Hexapla. He ought not to be

Origen.

Origenians ‖ Orinoco.

confounded with another Origen, a Platonic philosopher, and the disciple and friend of Porphyry, who studied philosophy under Ammonius. This Origen was perhaps the founder of the sect of Origenians.

ORIGENIANS (*Origeniani*) were ancient heretics. Epiphanus speaks of them as existing in his time; but their numbers, he says, were inconsiderable. He seems to fix their rise about the time of the great Origen; but he does not say that they derived their name from that distinguished father of the church. On the contrary, he distinguishes them from the Origenists, whom he derives from *Origen Adamantius;* adding, that they first took their name from one Origen, by which he intimates that it was not the great Origen. St Augustin also asserts that their founder was a different person. Their doctrines were infamous. They rejected marriage; they used several apocryphal books, as the acts of St Andrew; and they endeavoured to excuse their open crimes, by saying that the Catholics committed the same in private.

ORIGENISTS, in *Ecclesiastical History*, a Christian sect in the fourth century, so called from their deriving their opinions from the writings of Origen. The Origenists maintained that the souls of men existed in a prior state; that they were holy intelligences, and had sinned in heaven before the body was created; that Christ is only the Son of God by adoption; that he has been successively united with all the angelical natures, and has been a cherub, a seraph, and all the celestial virtues one after another; that in future ages he will be crucified for the salvation of the devils, as he has already been for that of men; and that their punishment, and that of the damned, will continue only for a limited time.

ORIGINAL, a draught or design of any thing, which serves as a model to be imitated or copied.

Original Sin. See Theology.

ORILLON, in *Fortification*, a small rounding of earth, faced with a wall, and raised upon the shoulders of those bastions which have casemates, to cover the cannon in the retired flank, and prevent their being dismounted by the enemy.

ORINOCO, or Oronoko, a river of Colombia, in South America. Like all great rivers, its upper waters separate into several branches, and it does not appear that the main source has been ascertained with any degree of certainty. According to La Cruz d'Olmedilla, it issues from a small lake called Ypava, situated in north latitude 5° 5′, whence, by a bend of a spiral form, it enters the lake Parima; but although the existence of this sheet of water has been determined, doubts are entertained whether it may not owe its origin only to the temporary overflowings of the river. From this lake it is said to issue by two mouths; and after a very circuitous course of upwards of fifteen hundred miles, including its windings, it flows into the Atlantic Ocean, opposite to the island of Trinidad, by about fifty mouths, seven of which are navigable. The Grande Boca, or principal mouth, which is six leagues wide, is south-east of Trinidad, in latitude 8° 30′ north, and longitude 59° 50′ west. A soft mud bank, formed by the debris brought down by the river, and of course just an extension of the delta of the Orinoco, which will one day be clothed with vegetation, stretches a considerable way into the ocean on the left of the grand mouth, forming one line of the channel to the entrance of the river. The other side of this channel consists of hard ground, covered with shells and shingles, and on which the water deepens and shoals continually. At its estuary it presents the appearance of a boundless lake, and for a great extent its fresh waters penetrate into the bosom of the ocean, almost uncontaminated by saline matter. "Its green-coloured stream," says Humboldt, "and its waves dashing over rocks in milk-white foam, are strongly contrasted with the deep blue of the sea, which is separated from them by a strongly marked line." Such is the force of the stream formed by the Orinoco between the main land and the island of Trinidad, that vessels overcome it with great difficulty, even when favoured by a fresh breeze from the west. This solitary and dreadful place, perpetually tormented as if by a whirlpool, is called the Melancholy Gulf, the entrance to which is formed by the Dragon's Mouth. There, in the midst of furious waves, says the great traveller just quoted, enormous rocks raise their isolated heads, the remains of that ancient dike which formerly joined the island of Trinidad to the coast of Paria. It was the aspect of these places which first convinced Columbus of the existence of the continent of America. The unrivalled navigator reasoned admirably when he concluded that such an immense body of water must have accumulated during a very lengthened course, and that the country through which it flowed must be a continent, and not an island. He, however, supposed it to be a continuation of the coast of Asia; and, from the ethereal clearness of the sky, the refreshing mildness of the evening air, and the aromatic odours which came wafted by breezes from the land, the Orinoco appeared to him to be one of the four streams which issued from the terrestrial paradise to fructify and divide the earth, and he believed that he was about to set foot in the garden of Eden

Orinoco.

Within the bar of the Orinoco the water gradually deepens, the force of the current continuing very considerable, and sometimes during the rainy season running at the rate of six miles an hour, so that navigation upwards is exceedingly difficult, except by steam-boats. At some distance within the Grande Boca of the river there is an island very thickly wooded, and forming the segment of a large circle. Indeed the magnificence of the scenery on the banks of the Orinoco is the astonishment of every traveller. Forests of boundless extent expand on either side, and, being filled with aromatic herbs and flowers that diffuse the most delightful odours, and all alive with birds of beautiful and glancing plumage, from the lovely mocking-bird to the grand vulture and fiery-red flamingo, together with hordes of monkeys, which disport from bough to bough, exhibit a richness, grandeur, and variety of scene which defies description. Passing these forests, enormous plains stretch out like oceans of verdure, far beyond the horizon embraced by the eye; and the sublimity of the scenery on the Orinoco is enhanced by several cataracts, of which Humboldt has distinguished and described those of Maypures and Atures. Their elevation is inconsiderable, and both owe their existence to an archipelago of little islands and rocks. The appearance of these rapids, however, is exceedingly picturesque and beautiful. "When the traveller descends from the village of Maypures to the brink of the river, after clearing the rock of Manimi, he enjoys a truly astonishing prospect. At once a sheet of foam stretches out before him, to fully a mile in extent. Masses of rock, of an iron-black colour, rear their rugged fronts, like towers, out of this misty cloud. Every island, every rock, is ornamented with luxuriant trees, closely grouped together. A thick smoke constantly hangs suspended over the water; and through this foggy vapour, which rises from the foam, shoot up the tops of lofty palm-trees. As soon as the burning rays of the setting sun mingle with this humid cloud, the optical phenomena which are produced actually give an air of enchantment to the scene. The coloured arches successively appear and disappear, and their image incessantly hovers before the eye at the mercy of the wind. During the long season of the rains, the murmuring waters have accumulated little islands of vegetable earth round the naked rocks. Adorned with the drosera, the mimosa with its foliage of silver white, and a multitude of other plants, these form beds of flowers in the midst of frowning rocks."

Orinoco.

The Orinoco is navigable, without difficulty, for two hundred and sixty leagues, to the rapids of Atures, where its mean height above the sea is, according to the traveller just quoted, not more than three hundred and fifty feet, and thence, after two short portages, for one hundred leagues more, to the point near Esmeraldo, where the celebrated bifurcation of this river takes place, and a portion of its waters descends along the natural Canal of Casiquiari, to join the Rio Negro and the Amazon. The communications which exist between the Orinoco and the Amazon constitute one of the most astonishing phenomena of physical geography. More than half a century has elapsed since the fact was made known by the Portuguese; but for a long period after this it was pertinaciously maintained by systematical geographers, that such conjunctions of rivers were impossible. By the enterprise and perseverance of recent travellers, however, it has been proved that this is no anomaly; and we no longer stand in need of either analogies or critical reasoning to support the fact. M. de Humboldt has navigated both these rivers, and examined and described this singular arrangement of the land. It is now put beyond a doubt, that the Orinoco and the Rio Negro flow along a plateau, which at this part has no actual acclivity. A valley then intervenes, their waters flow into it, and there unite, thus forming the celebrated Casiquiari, by means of which MM. Humboldt and Bonpland passed from the Rio Negro into the Orinoco. It is believed that there are also other communications between the Rio Negro and the different tributaries of the Amazon. On both sides along its course the Orinoco receives many tributary streams, of which three in particular, the Apure, the Meta, and the Guaviare, flowing from the westward, have also long navigable courses. The Apure falls into the Orinoco about four hundred and forty miles from the mouth of the latter river, in latitude 7. 36. 23. north, and longitude 69. 7. 29. west. The course of the Apure is as serpentine as that of the Orinoco, only on a much smaller scale, the tributary being in no part of its course much more than a musket-shot across. At rather more than one hundred miles from the confluence of the two rivers is San Fernando de Apure, a considerable town in the province of Apure, and a place of some commerce. From thence the navigation is continued, partly on the Apure and partly on the river Santo Domingo, to Toruno and Varinas, at a distance of above two hundred miles farther. The line of navigation of this branch of the commerce of the Orinoco extends, therefore, nearly eight hundred miles from the mouths of the river to the extremity of the province of Varinas. About sixty miles below the cataracts, the Orinoco receives the Meta, a river which, issuing from the paramos of Cundinamarca, keeps its course parallel to them for a hundred and fifty miles, receiving in its progress their tributary streams; and then bending to the east, crosses the llanos of Casanare, and completes a course of more than four hundred miles before its confluence with the great river.

At some future period the navigation of the Meta will become an object of very great importance to Guiana, and all the other eastern departments of the republic. The Guaviare is also a very considerable navigable river, formed by a number of streams which flow down the eastern declivities of the Andes. It joins the Orinoco at San Fernando de Atabapo, in latitude 4° 3′ north, and longitude 68° 10′ west, which is the point where the Orinoco takes a great bend to the north. When steam navigation shall have become common in this quarter of the world, the river Guaviare will prove of immense advantage to some of the interior provinces of Colombia, as a medium through which their produce may be conveyed to the sea-ports of the republic. There are a great number of other streams, tributary to the Orinoco, no less than three hundred being enumerated. Many of the upper streams of this river display the singular phenomenon which has been called "black waters." Under the shadow of the palm-trees their colour becomes of a deep black, but, in transparent vessels, it assumes a yellow hue. The absence of crocodiles and fish (which are very plentiful farther down), a greater degree of coolness, a smaller number of musquitoes, and a more salubrious atmosphere, distinguish the region of the black waters. Humboldt surmises that they derive their colour from a solution of carburet of hydrogen, resulting from the decomposition of the multitudes of plants that cover the soil through which they flow. With regard to the breadth, depth, and quantity of water discharged by the Orinoco, as well as the size of the delta which it has formed, our information is by no means precise. At six hundred miles from the ocean it is said to be from five to six hundred yards across, and at Angostura or St Thomas's, situated two hundred and forty miles from its mouth, to be nearly eight hundred yards across. Its depth appears to be very great; even when the waters are at the lowest, it is no less than sixty-five fathoms in some parts; and during the rainy season it inundates the immense plains through which it flows, extending during the highest floods from eighty to ninety miles on either side, and thus presenting to the eye the appearance of a vast inland sea, rather than a river. These facts, together with that of the vast extent to which the current of the river may be traced in the ocean, are sufficient to prove that the quantity of water brought down by the Orinoco is inferior to that of few rivers on the face of the globe. The annual swell of the Orinoco commences in April and ends in August. At the distance of thirteen hundred miles from the ocean the rise is about thirteen fathoms. In the beginning of October the water begins to fall, and, quitting the deluged plains, continues to diminish till March, when it is at the lowest ebb. This river abounds in fish of various descriptions. Amphibious animals are also found in great numbers on its shores; the cayman or alligator frequents its waters, and is very formidable. From one of the best maps of Colombia which have been published, it appears that its delta extends above one hundred and fifty miles in length at the base, and that from the middle of this line to the apex of the triangle it is above one hundred miles in depth. (R. R. R.)

Orion.

ORION, in fabulous history, was the son of Jupiter, Neptune, and Mercury. As these gods were visiting the earth, they entered the house of Hyrieus, a native of Tanagra, in Bœotia, under the character of benighted travellers, on account of his being famed for hospitality to strangers. Hyrieus treated them in the best manner possible; and even killed an ox, the only one he had, for their entertainment. With this the gods were so pleased, that they offered the old man whatever he should ask; and he having let them know that he desired nothing so much as a son, they, anxious to gratify his wish, caused the ox's hide to be brought before them, and having deposited in it their urine, bade him keep it under ground for nine months. He then dug for the skin, and found in it a beautiful child, whom he called *Urion*. The name was afterwards changed into Orion, by the corruption of one letter, as Ovid observes: *Perdidit antiquum littera prima sonum*. Orion soon became conspicuous, and Diana admitted him amongst her attendants, and even became deeply enamoured of him. His gigantic stature, however, displeased Oenopion king of Chios, whose daughter Hero or Merope he requested in marriage. The king, not willing to deny him openly, promised to make him his son-in-law as soon as he should have delivered that island from wild beasts. This task, which Oenopion supposed to be impracticable, was soon performed by Orion, who eagerly demanded his reward. Oenopion, on pretence of complying,

Orissa.

made his illustrious guest drunk, and in this state put out his eyes on the sea-shore, where he had laid himself down to sleep, so that Orion, when he awoke from his debauch, found himself blind. Directed by the sound, he then went to a neighbouring forge, where he placed one of the workmen on his back, and by his directions proceeded to a place where the rising sun was seen with the greatest advantage. Here he turned his face towards the luminary; and, according to report, he immediately recovered his eye-sight, and hastened to punish the perfidious cruelty of Oenopion. Orion was believed to have been an excellent workman in iron, and to have fabricated a subterranean palace for Vulcan.

Some say that Orion was the son of Neptune and Euryale, and that he had received from his father the privilege and power of walking over the sea without wetting his feet; but others assert that he was a son of Terra, like the rest of the giants. He had married a nymph called Sida before his connection with the family of Oenopion; but Sida was the cause of her own death, by boasting herself fairer than Juno. Diodorus says that Orion was a celebrated hunter, superior to the rest of mankind by his strength and uncommon stature. He built the port of Zancle, and fortified the coast of Sicily against the frequent inundations of the sea, by heaping up a mound of earth called Pelorum, on which he built a temple to the gods of the sea. After his death Orion was placed in heaven, where one of the constellations still bears his name. The constellation of Orion was placed near the feet of the bull. It was composed of seventeen stars, in the form of a man holding a sword; for which reason the poets often speak of Orion's sword. As the constellation of Orion, which rises about the 9th day of March, and sets about the 21st of June, is generally supposed to be accompanied at its rising with great rains and storms, it has acquired the epithet of *aquosus*, which is applied to it by Virgil.

ORISSA, an extensive province of Hindustan, in the Deccan, between the sixteenth and twenty-third degrees of north latitude. It has Bengal for its boundary to the north, to the south the river Godavery, to the east the Bay of Bengal, and to the west the province of Gundwana. It may be estimated from north-east to south-west at 530 miles in length by ninety in average breadth. Orissa was formerly an independent Hindu kingdom. It was first conquered by the Afghans, and afterwards by the Moguls towards the end of the sixteenth century. It was in ancient times divided into five districts, namely, 1. Jellasir, comprising Midnapoor and the British possessions lying north and east of the river Subunreeka; 2. Buddruck (now Cuttack); 3. Cuttack; 4. Kulling or Cicacole; and, 5. Rajamundry. The principal modern subdivisions of this extensive province, independently of other petty states and large zemindaries, are, 1. Singhboom; 2. Kunjeur; 3. Mohurbunge; 4. Balasore; 5. Cuttack; 6. Khoordah.

This province, in the interior, is of a rude and barbarous aspect, consisting for the most part of rugged hills, uninhabited jungles, and deep water-courses. It is surrounded by pathless deserts, forests, or valleys; and the atmosphere is pestilential. There are only two passes in the great mountainous ridge that extends from the Godavery to the Mahanuddy; the one direct, from Chandah to Cicacole; the other oblique, from Choteesghur by the way of Kaluhindi, and both uniting at the pass of Saloor or Saureacca. But though Orissa is, generally speaking, a barren country, the south-eastern or maritime parts are equal in fertility to most parts of India.

At present the British rule over nearly one half of this extensive region, and the remaining part is possessed by tributary zemindars, called ghurjauts or hill-chiefs, who pay a fixed rent to the British, under whose jurisdiction they live. The woody and interior division of the country belongs to them; whilst the other division, belonging to the British, comprehends all the low lands extending along the coast, a tract generally plain and fertile, but not well cultivated or peopled. But the country occupied by the natives, though a barren tract of rock, forest, and jungle, and thinly inhabited, produces a surplus of grain beyond the consumption of its inhabitants. The British portion of the country produces, as its chief staples, rice and salt, the former of which is an article of export. Every sort of grain and vetch is cultivated, and the country is improving under its present administration; whilst the portion that is still under its native chiefs presents a scene of oppression and decay. The low lands along the Bay of Bengal abound with wild animals, such as hogs, deer, tigers, and jackalls; and the high lands are infested by such numbers of wild animals, that in many places they are regaining possession of the country from which they were driven by the progress of cultivation. Fish swarm in the rivers, which are also infested with reptiles and alligators; and in the plains and jungles are innumerable noxious insects. The chief rivers are the Godavery, Mahanuddy, Byturnee, and Subunreeka, besides innumerable mountain streams of a short course.

Oristano || Orkney Islands.

The country between the rivers Gaintee and Bamoni is peculiarly fertile, and is inhabited by an industrious class of persons, weavers, chiefly of coarse muslins for turbans, and sanaes, which are a staple manufacture. The districts to the west of Bengal are mountainous, and inhabited by a savage race of Hindus, who are still called Oureas. They go nearly naked, and are armed with bows and arrows, and are nominally subject to the Mahrattas, though they pay but little revenue. They are naturally a fierce people, possessing personal courage in a great degree. They are great enemies of the Mahrattas, who plunder and oppress them; but those under the British dominion are a mild and tractable people, and the palanquin-bearers in Calcutta are mostly from that country. These bearers have high and proud notions: they pretend to be of a higher caste than the bearers from Bahar, and are very fastidious about performing their duties.

In the ancient history of the Hindus, Utcala or Odradesa, implying the great or famous country of Cala, was nearly co-extensive with the modern Orissa; but the martial race by whom it was inhabited were at last extirpated by the karnas or kings of Magadha. A race of Hindu princes governed the country in 1592, and were conquered by the viceroy of Akbar, to whose dominion the country was annexed as a dependent government. It then measured 600 miles along the sea coast by forty in medium breadth, extending from Tumlook on the banks of the Great Ganges, to Rajamundry on the Lesser Ganges; and was inhabited by the Oureas, a race of Hindus, of peculiar and distinct language, manners, and religion. From disjointed fragments of its history, and from existing relics, it appears to have been a flourishing empire, even before the Mahommedan invasion; but it soon afterwards fell into decay. When the Afghans were expelled from Bengal by the Moguls in the sixteenth century, they took refuge in Orissa, and retained possession of part of it, including the celebrated temple of Juggernaut, till near the year 1615. (F.)

ORISTANO, a city of the island of Sardinia, situated on the western side of the gulf or bay of that name. It is the seat of an archbishop, and has a cathedral, a nunnery, several monasteries, and a harbour about a mile from it, into which the river Oristano enters. The air is very impure. Oristano contains 4990 inhabitants.

ORIZAVA, a town of Mexico, in the state of Vera Cruz. See the article MEXICO.

ORKNEY ISLANDS, or ORCADES, a group of islands in the North Sea, belonging to and forming with the Zetland Islands one of the counties of Scotland. They are sepa-

Orknev. rated from Caithness by the Pentland Firth, a strait of about twelve miles in breadth, and are situated between the parallels 58. 44. and 59. 24. north latitude, and between 2. 24. and 3. 20. west longitude from the meridian of Greenwich. In number they amount to sixty-seven, of which twenty-seven are inhabited; and the others, known by the name of *holms*, are employed as grazing grounds for sheep and cattle, and for the manufacture of kelp. The islands are divided into two groups, called, in reference to Pomona, the principal island, the North and South Isles. The following are the names of the inhabited islands in the southern division, with their population according to the census taken in 1831:

South Ronaldshay	2265
Walls and Hoy	1388
Flotay and Faray	369
Burray	357
Græmsay	225
Swanay and the Skerries	89
Copinshay	7
	4700

The following are the names and population of the North Isles:

Sanday	1839
Westray	1702
Stronsay, Papa Stronsay, and Lingholm	1071
Rousay	921
Shapinshay	809
Eday and Pharay	756
North Ronaldshay	522
Papa Westray	330
Egilshay	228
Weir	93
Gairsay	69
Enhallow	20
	8360

Pomona, or the Mainland, has a population of 15,787, and thus the whole number of inhabitants amounts to 28,847.

Orkney has been computed to contain 150,000 square acres, and, of these, 100,000 are said to be waste, or covered by water. But the very irregular form of the islands, penetrated by arms of the sea in all directions, renders these estimates, in absence of any accurate survey, nothing more than approximations. The general appearance of the islands is bleak, and upon the whole uninteresting. The total want of wood, and the immense tracts of waste, uncultivated land, present a very forbidding aspect.

The climate is exceedingly moist, and, though the cold is not very intense, the variable weather renders the winter disagreeable in the extreme. For several months there is a succession of rain, sleet, and storms. Spring is late, damp, and cold; but an Orkney summer, though short, has many and peculiar charms. The length of the day, the duration of twilight, the rapid vegetation, and, above all, the stillness of the sleeping ocean on a calm evening, compensate in no small degree for the dreariness of the other seasons.

Orkney is divided into twenty parishes, composing three presbyteries and one synod. Together with Zetland, these islands constitute one sheriffdom or stewartry, under the jurisdiction of a sheriff-depute and two substitutes, whose courts are held at Kirkwall in Orkney, and Lerwick in Zetland. Till the passing of the reform bill, Orkney alone had the privilege of sending a member to parliament; the landholders of Zetland, owing to the want of a separate valuation of their estates, having no vote in the election. Of the land-tax payable for the county, two thirds are levied from Orkney, and one third from the other division of the stewartry.

We shall now proceed to notice the principal islands, pointing out the most remarkable objects in them. The Orknev. most southerly is South Ronaldshay, containing twenty-four square miles, and a population of 2265 persons, chiefly employed in agriculture, and the lobster, cod, and herring fisheries. There are two commodious and secure harbours in this island, Widewall Bay on the west, and St Margaret's Hope on the north. The antiquities of the island are several Picts' houses, three or four monumental stones of large size, and the How of Hoxa, an ancient stronghold. To the north-west of South Ronaldshay lies Hoy, an island of twice the extent, but containing only 1388 inhabitants, the greater part of it being high land covered with heath. This is in many respects the most interesting of all the islands. The Wart Hill, the highest mountain in Orkney, its towering precipices washed by the fury of the Western Ocean, the huge isolated rock called "the Old Man of Hoy," the meadows of the Kaim, the beautiful vale o. Berrydale, through which flows a stream whose banks are fringed with birches, creeping juniper, and willows, and the dwarfie stone, present to the spectator objects which will amply repay a lengthened visit. Forming part of the island of Hoy, but constituting a different parish, is Waas, or Walls, distinguished chiefly for its excellent harbour, Long Hope, which is now protected by a small battery and a couple of martello towers. Burray, situated to the north of South Ronaldshay, and separated from it by a channel of a mile in breadth, has an area of only three square miles, but produces grain, green crops, and good pasture, and has, moreover, a valuable rabbit warren. Farther north is the largest island of the group, Pomona, or Mainland, extending to thirty miles in length, and containing upwards of two hundred square miles. The towns of Kirkwall and Stromness are in this island (see articles KIRKWALL and STROMNESS). Pomona is divided into thirteen parishes, which are supplied by eleven clergymen. Of these divisions, if we except St Ola, or Kirkwall, Stennis has the greatest claims on the attention of the traveller or the antiquary. Here are the Stones of Stennis, two collections of what at one time must have been upright pillars, forming a circle and a semicircle. Many of these stones are now overthrown; but the circle, when complete, seems to have been formed of thirty-five blocks; its diameter is three hundred feet, and the stones of which it is composed vary from ten to sixteen feet in height, and from two and a half to five feet in breadth. There have been many conjectures as to the purpose of these erections, and it is by no means certain even by whom they were raised. One opinion is that they are of Druidical, and another that they are of Scandinavian origin. A very probable conjecture is, that the circle was dedicated to the sun, and the semicircle to the moon, the frequent objects of Scandinavian worship. Of these stones the most interesting was one which stood near to, but did not form part of, the circle; it was perforated by a small hole, through which the heads of children were passed in order to secure them against palsy in after-life, and through which also lovers' hands were joined, in token that the vows then made should be faithfully kept. The contracts or agreements here made were peculiarly binding, and the promise of Odin was regarded by an Orkneyman as of too solemn a nature to be trifled with. The malice or stupidity of a stranger, who rented a neighbouring farm, induced him, in 1814, to overthrow and break to pieces this curious relic of ancient times. In front of the circle there is a large horizontal stone, conjectured to have been used for sacrificial purposes; and it has been thought that it was on this altar that Einar, jarl of Orkney, son of Ronald, about the year 893, or, according to other accounts, 930, stretched Halfdan, the son of Harold the fair-haired, king of Norway, and, tearing out his lungs, presented the reeking gift to his god. In the adjoining parish of Sandwick, the gran-

Orkney. deur of the rocks must attract the attention of the visitor; and one huge archway, formed by the restless fury of the waves, called the Hollow Row, or the Hole of Row, is particularly deserving of attention. Robert Steuart, earl of Orkney, had a palace in Birsay, the next parish on the north-west, the ruins of which still remain. Brand, who visited the county in 1700, says, "the palace is two stories high, the upper hath been prettily decored, the ceiling being all painted, and that for the most part with schems holding forth Scripture histories, as Noah's flood, Christ's riding to Jerusalem, &c. and the Scripture is set down beside the figure. It was inhabited within these twenty years, but is now fast decaying." The writer of this article saw it in 1820. All the decorations, the roof, and a great part of the walls, were then gone; and the clergyman of the parish informed him that the palace was regarded as a common quarry, whence every intending builder drew materials for the erection of his house. It was over the gateway of this building that the inscription was placed which is said to have been adduced as evidence of the treasonable designs of the family on the trial of Patrick, Earl Robert's son: "Dominus Robertus Stuartus, filius Jacobi quinti, *rex* Scotorum, hoc opus instruxi." The two islands of Shapinshay and Rousay, each containing from ten to twelve square miles, lie to the north of the Mainland. In the former lead ore has been found, but not in quantities sufficient to remunerate the miner; and the latter presents to the antiquary for his investigation, tumuli, Picts' houses, standing stones, and a number of ancient graves. To the east of Rousay is the beautiful island of Egilshay, the favourite summer residence of the ancient jarls, and, at a later period, of the bishops of Orkney. It was here that St Magnus, the tutelar saint of the islands, was basely murdered by his cousin Hacon, in 1110. Beyond these, to the north-east, lie Stronsay, where there is an extensive fishing station; and Eday, an island that can boast of a burgh of barony. Still farther north lie Sanday on the east, and Westray on the west. The former, because of its superior productiveness, has been called the granary of Orkney; and it produces, or rather did produce, fully one fifth of the kelp manufactured in all the islands. It is a flat, low-lying island; and, till the erection of a lighthouse in the year 1806, proved fatal to many a vessel. Westray is, with the exception of Sanday, the largest of the north isles. In it are the remains of a strong castle, of which Ben, who wrote in 1529, thus speaks: "Est excellentissima arx sive castellum, sed nondum tamen adhuc completa." A great many graves, generally formed of five flat stones, four standing on their edges, and resting on the fifth, have been lately uncovered, in consequence of sand blowing. In them have been found the remains of human bones, and of various weapons, offensive and defensive. In all probability they are the graves of natives and strangers, who had fallen in some of the many battles of which tradition preserves the remembrance. Separated from Westray by a frith of a mile in breadth, is the small island of Papa Westray, with its beautiful fresh-water loch, in the middle of which is a small island, whereon stood the chapel of St Tredwall. The most northerly of the islands is North Ronaldshay, containing an area of from four to six square miles, with a population of 522. It was on a reef near this island that the Suetia of Gottenburg, an Indiaman, valued at half a million sterling, was wrecked in 1740; and here, too, four years afterwards, another Indiaman, the Crown Prince of Denmark, with thirty chests of treasure on board, was cast away. About the year 1790, a lighthouse, seventy feet in height, was erected on the north-east point of the island; but this light being often mistaken for that in Sanday, misled mariners, and it is now discontinued, the latter being regarded as sufficient.

The geology of these islands offers little to attract our attention. The Orkneys are said to consist of an assemblage of secondary strata, disposed round a high central nucleus of primitive rocks; but Professor Traill remarks, that "the mineral history of Orkney is singularly monotonous and uninteresting; the whole islands, with slight exception, consisting of horizontal or slightly inclined strata of sandstone, flag, and a species of slaty clay, occasionally intermixed with thick beds of red and gray sandstone, and, in a few places, containing beds of limestone, with some traces of marine remains." Orkney.

The Orkney Flora is known to consist of 545 species, to which it is probable that a careful examination will make some additions. The *chara aspera*, discovered by the Rev. Charles Clouston, minister of Sandwick, is the only Orkney plant new to the British Flora.

The zoology of Orkney, according to the *Fauna Orcadensis* of Low, is as follows: Quadrupeds, eleven genera; birds, thirty-four genera; reptiles, two genera; and fishes, twenty-three genera. To these a few additions, we believe, have been made.

The history of the islands will not detain us long. They seem to have been originally peopled by a Scandinavian tribe; but little certain is known till the year 870, when the Norwegian chiefs, who had fled from home because of the victories of Harold the Fair-haired, arrived there. Harold pursued them six years afterwards, defeated them, and appointed Ronald count of Moere jarl or earl of Orkney. He was succeeded, after an interval and some changes, by his son Einar; whilst another son of his, Rollo, wrested Normandy from Charles the Simple, king of France, and, becoming duke of that province, was the great-great-great-grandfather of William the Conqueror. The descendants of Ronald ruled as jarls for upwards of four hundred years, when the male line terminated in the person of Magnus, the fifth earl of that name. He died about 1320 or 1330, leaving one daughter, Matilda, who became the wife of Malise, earl of Stratherne, and had issue Isabell, who married Sir William St Clair, baron of Rosslyn; and the son of this marriage, Sir Henry, was the first of the *Scottish* Earls of Orkney. His title was admitted by Hacon VI., king of Norway, in 1379. By a treaty entered into before this period, between the courts of Scotland and Norway, the latter ceded to the former Man and the Western Islands, for the payment of a certain yearly sum called the "Annual of Norway." This tribute, not having been regularly rendered, soon amounted to a large sum; but, after much negotiation on the subject, it was arranged that the arrears of the *annual* should be held as discharged, that James III. should marry Margaret of Norway, that her dowry should be 60,000 florins, and that Orkney should be impignorated to Scotland for five sixths of that sum, the islands to be redeemed on the payment of the money. This treaty was entered into in 1468. The marriage-portion was never paid, and it has given rise to much controversy, whether the claim of Norway to these islands has been ever formally relinquished; a question into which we shall not enter, as it has been for centuries practically resolved. The earldom remained in the family of St Clair till 1471, when it and the title merged in, or rather was united to, the crown of Scotland, never again to be alienated, except in favour of a lawful son of the king. For almost a century the crown-lands were leased to various tenants, till at length, in May 1564, Queen Mary granted a charter to Lord Robert Stuart, her father's son by Dame Euphemia Elphinstone, constituting him Earl of Orkney. Afterwards, by her marriage-contract with Bothwell, dated May 1567, Mary bound herself to create him Duke of Orkney, and to put him in possession of the islands. He appears never to have been infeft, or, at all events, a month after the marriage, he fled, and the duke-

Orkney.

dom was at an end. Earl Robert had no concern with Orkney from 1567 to 1581, but in the latter year he had another grant of the earldom made to him. This was revoked by King James upon his attaining his majority in 1587. Again, a farther grant was executed in favour of him and his heirs in 1591, which in 1592 was confirmed by parliament. Earl Robert died in that year, and the earldom was once more resumed by the crown; and once more, in March 1600, Patrick, the son of Robert by the Lady Jean Kennedy, got a grant of it in his favour; and in May of the same year he got a grant of the bishopric. Earl Patrick's crimes brought him to the scaffold in 1615; and after his death the Orkneys were again unalienably annexed to the crown, and again they were alienated in 1643. This deed was declared null and void in 1669; and once more, in 1707, they were mortgaged to the Morton family, burdened with an annual payment of L.500 to the crown. In 1742, this mortgage was declared irredeemable, and Lord Morton in 1766 sold his rights for L.60,000, to Sir Laurence Dundas, in whose family they still remain. From a calculation made by Sheriff in his agricultural survey, printed in 1814, it would appear that Lord Dundas draws annually from his vassals in the earldom L.2187. 11s. $9\frac{23}{24}$d., payable partly in money and partly in produce. In addition to this he has a large private property in the county.

Of the trade and manufactures of Orkney, it is not easy to give any thing like an accurate estimate; but the following may be looked upon as generally correct.

Years.	Exports.	Shipping.	Ships.	Sailors.
	L.	Tons.		
1770	12,018	825	17	76
1780	23,257	940	20	90
1790	26,598	2000	23	170
1800	39,677	1375	21	119
1820	...	2841	46	300
1833	...	4049	78	319

The exports consist chiefly of grain, fish, cattle and sheep, butter, hides, rabbit-skins, and eggs. In 1833, it is said, 100,000 dozens of eggs were exported, which, at 6d. a dozen, brought L.2500. The imports are of a most miscellaneous description, and we have seen no probable estimate of their value.

Till lately, the principal manufacture in the islands was that of kelp, which at one time brought L.12, L.16, and even L.20 a ton; but now the prices obtained barely suffice to cover the expenses of making and carrying it to market. The greatest quantity ever made in one year was in 1826, when 3500 tons were manufactured, which, on an average, sold at L.7 a ton. The expense of cutting, drying, and burning the sea-weed, amounts to about L.3 or L.3. 3s. a ton of kelp, and it costs about L.1 more to bring it to market; and, for some years, the price has scarcely exceeded L.4. 10s. or L.5.

In 1833 there were forty vessels of about thirty tons each engaged in the cod-fishery, and they caught and cured 560 tons of fish, valued at L.13 per ton. During the same year, the produce of the lobster-fishery, in which there were engaged 216 boats and 432 men, amounted to L.1800. The principal fishery, however, is the herring-fishery. In 1820 there were exported from Orkney 17,989 barrels of herrings, which, at 10s. a barrel, would amount to about L.8000; and in 1833 the number had amounted to 34,000 barrels, valued at L.17,000. The principal stations for this fishery are Huip in Stronsay, and St Margaret's Hope in South Ronaldshay.

The chief manufacture in Orkney at present is that of straw-plaiting. Twenty years ago, from six to seven thousand females were employed in this branch of trade; and they are calculated to have drawn in wages L.20,000 annually. Since that time the plaiting of common straw has been almost entirely discontinued, and that of the unsplit straw of rye or wheat has been introduced. In 1833 there were plaited 489,560 yards of Orkney straw, and 240,900 yards of foreign straw. The former is thought tougher than the latter, but the colour is not so pleasing. A bonnet that will cost L.4 contains about 140 yards of the finest plait.

In Kirkwall there are two licensed distilleries, and there is one in Stromness. In 1833 there were distilled 13,947 gallons of whisky, yielding to the revenue L.2324. 10s. of duty. It has been calculated, that during the year to which these estimates chiefly refer (viz. 1833), upwards of L.60,000 was received in Orkney, principally from fisheries, farm produce, and manufactures.

When Dr Barry wrote his history of Orkney, more than thirty years ago, he pointed out many defects in the system of Orkney farming. Some of these still remain, but many of them have disappeared; and, as old prejudices wear away, and landlords see that it is for their own no less than for their tenants' advantage to grant leases of some duration, and when both parties are convinced that a proper rotation of crops should be insisted on, and when fencing and draining have been carried to a greater extent than has yet been done, we may hope to witness a still more marked improvement. The grain almost exclusively raised in Orkney is barley, or rather bear or big (*hordeum tetrastechon*), and gray oats (*avena strigosa*). We have seen wheat tried, but the result of the experiment was not encouraging.

In conclusion, we would remark, that the inhabitants of these islands are in general not overmuch inclined to labour when at home, but that when abroad they can be made to exert themselves. They are somewhat superstitious, but are nevertheless well informed on many subjects; whilst the upper classes, as a body, are not inferior to their equals in station in any part of Scotland. All classes are universally acknowledged to be kind, courteous, and most attentive to strangers.

(*Orkneyinga Saga;* Torfæi *Rerum Orcadensium Historia;* Brand's *Brief Description of Orkney, &c.;* Wallace's *Description of Orkney;* M'Kenzie's *Greevances of Orkney;* Fea *On the Fisheries of Orkney;* Low's *Fauna Orcadensis;* Barry's *History;* Sheriff's *Agricultural Scenery;* Neill's *Tour;* Peterkin's *Rentals and Notes;* Groat's *Thoughts on Orkney.*)

Orle ‖ Orleans.

ORLE, ORLET, or *Orlo*, in *Architecture*, a fillet under the ovolo, or quarter round, of a capital. When it is at the top or bottom of a shaft, it is called *cincture*.

ORLEANS, an arrondissement of the department of the Loiret, in France, extending over 892 square miles. It comprises fourteen cantons, divided into 106 communes, and in 1836 contained 141,637 inhabitants. The capital is the city of the same name, being the seat of a bishop, and of the departmental boards of the government and courts of law. It stands on the right bank of the Loire, over which there is a fine bridge of sixteen arches. It is surrounded with walls, which, being planted with trees, form pleasing promenades. In general, it contains anciently built houses, and narrow streets, though there is one exception in the suburbs. The cathedral is a fine old building, as well as the town-house, and the châtelet, formerly the residence of the Duke of Orleans. There are five hospitals, an exchange, an academy, a lyceum with a library of 36,000 volumes, and a theatre. The city contains 4600 houses, with 40,272 inhabitants. It is a place of extensive trade, having manufactories of serges and other woollens, several sugar-refineries, distilleries, breweries, and china-works. It is also a dépôt for the wines of Languedoc and Guienne,

Orleans, Peter Joseph || Orme.

and for brandies of its own preparation, as well as for those of Cognac, Chinan, Samur, and Blois. It has long given a title to a branch of the Bourbon family, and has been much celebrated for its defence under the famous Maid of Orleans. Long. 1. 49. 23. E. Lat. 47. 54. 10. N.

ORLEANS, NEW, a city of Louisiana, one of the United States of North America. See LOUISIANA.

ORLEANS, *Peter Joseph*, a French Jesuit, was born at Bourges in 1641. He taught belles-lettres for some time in his society, but afterwards devoted himself to the writing of history; and this pursuit he continued till his death, which happened in the year 1698. He wrote a History of the Revolutions of England; a History of the Revolutions of Spain; a History of two conquering Tartars, Chunchi and Camhi; the Life of Father Coton; and some other pieces. His History of the Revolutions in England, under the family of the Stuarts, from the year 1603 to 1690, was translated in English, and published at London in 1711, one vol. 8vo; to which is prefixed an Introduction, by Mr Laurence Echard, who says, that "the great varieties and wonderful changes in these reigns are here judiciously comprised in a moderate volume, with no less perspicuity than strictness, and with a beautiful mixture of short characters, nice reflections, and noble sentences, which render the whole agreeable and instructive."

ORLOP, in nautical language, the uppermost space or deck in a great ship, reaching from the main to the mizen-mast. In three-deck ships, the second and lowest decks are sometimes called *orlops*.

ORME, ROBERT, the historian of British India, born at Anjengo, in Travancore, was the son of Dr Alexander Orme; and his mother was a Miss Hill, a sister of Mrs Robert Adams.

He was sent to England at the age of two years, and placed under the care of Mrs Adams, who lived in Cavendish Square. His literary education commenced very early, for he went to Harrow at six, having been previously, for a twelvemonth, under the private tuition of a clergyman in the neighbourhood. For seven or eight years he applied to his classical studies as a school-boy with great diligence; and when he was thirteen, he was placed in the office of the accountant of the African Company, in order to gain some practical knowledge of the principles of commerce.

In 1742 he went out to Calcutta, and was there engaged in a mercantile house of respectability; he made a voyage to Surat in their concerns, and on his return, in 1743, he received from England the appointment of a writer. Five years afterwards he was promoted to the rank of factor in the company's service. In 1752, having been desired to give his opinion on the regulation of the police of Calcutta, he drew up a memorial on the subject, which did great credit to the accuracy and profoundness of his views of the manners, the habits, and the interests of the country.

He returned to England in 1753, upon a visit to his aunt, and he was much consulted, during his stay in London, by Lord Holderness, then secretary of state, with regard to the policy to be observed towards the French government respecting the affairs of India. He went out again in 1754, and took his seat as a member of the council at Fort St George. He had here an opportunity of effectually serving the company by the vigour of his political conduct, and of greatly contributing to the establishment of the decided preponderance of the English interest in India. After the well-known affair of the Black Hole of Calcutta, he was particularly active in promoting the appointment of Colonel Clive to the command of the expedition destined to punish the cruelty of the tyrant who was the author of that outrage; although his friendship with Colonel Clive did not continue uninterrupted through life. Mr Orme's exertions on this and other occasions were so highly appreciated by the directors, that he was nominated as eventual successor to the government of Madras; but he did not stay long enough to profit by the appointment. In the capacity of accountant-general, he became intimate with Mr Alexander, afterwards Lord Caledon, who was his deputy, and with Mr Dalrymple the hydrographer, to whom he showed many civilities, from a conviction of his merits. Mr Benjamin Robins, the historiographer of Anson's Voyage, had also been one of his early friends, that is, during his first residence in India; for this singularly active person died in 1751. Orme.

Mr Orme's situation in India was extremely favourable for the acquisition of historical information, which it was the delight of his life to collect; but his health requiring a change of climate, he sailed for Europe on board of the Grantham in 1758. The ship, however, was captured in January 1759, off the Cape of Good Hope, and carried to the Mauritius; but after having been detained there for some time, Mr Orme was allowed to proceed to the Cape, and thence to France. Having landed at Nantes in the spring of 1760, he paid a visit to Paris, where he amused himself for some months with the literature and the theatres of the day; and his biographer has preserved some interesting remarks that they suggested to him. In October he arrived in London, and engaged a house which had been lately built in Harley Street.

He employed himself for the two succeeding years upon his Military History, sparing no pains nor expense to complete the collection of materials, which he had begun to form in India, and to prepare the work, with all possible care, for the press. The first volume appeared in 1763, and was received with great approbation. The company not only granted him free access to their records, but gave him also the appointment of their historiographer, with a salary of L.400 a year. After this time, he resumed some of his classical studies, which he had discontinued so long as to have forgotten almost all that he had learned; but he soon recovered his knowledge of the ancient languages, and added to them afterwards such of the modern ones as he found likely to be subservient to his pursuits. His hours of leisure were chiefly passed in the enjoyment of literary society; he became a fellow of the Society of Antiquaries in March 1770; and about the same time he became intimate with Lord Sandys, and with Sir James Harris. Sir William Jones, Dr Robertson the historian, Dr Pemberton, Dr Wilson, Athenian Stuart, and Nourse the bookseller, were also among his particular friends; as well as Mr Rouse Boughton, afterwards Sir Charles Rouse Boughton, to whose urbanity and thorough acquaintance with the Persian language he was indebted for several of his historical documents. He obtained additional information for the completion of his History from the French general De Bussy, who had been much concerned in some of the transactions narrated in his first volume, and who was so much satisfied with his candour and impartiality that he invited him to his house in the country, and entertained him there, in 1773, with great kindness and hospitality.

After the publication of the second volume of his History, he had ample leisure to amuse himself with literary pursuits of a more general nature; but in 1784 he suffered a severe affliction from the loss of his nephew, Mr Hosea, who was shipwrecked, with his wife and family, upon their return from India, on board of the Grosvenor. In 1792 he retired to Ealing, where he continued to reside till the time of his death, which happened on the 13th of January 1801.

Good sense and sound judgment were the principal features of his character. His works are more distinguished by simplicity, clearness, and precision, than by any very powerful eloquence, or a very nice discrimination of cha-

Ormea ‖ Ormskirk.

racter. He was not, however, deficient either in command of language or in poetical feeling. Sir William Jones and Dr Robertson paid him some very high compliments, in their private correspondence, for the elegance and purity of his style; and the former of these writers has also characterized him, in his third Discourse, as possessing an "exquisite taste for every fine art." We find also, amongst a few miscellaneous poems collected by his biographer, a remarkable little Address to the Moon, written at Madras in 1757, which is manifestly the original of a well-known Greek epigram and a Latin ode of Sir William Jones; and certainly the compliment of having been "set to music, and much admired," must be considered as far inferior to that of having been repeatedly imitated and translated by a poet of a judgment so correct, and a taste so refined, and having been called the production of "a man of great talents, and a particular friend of the translator."

1. Of his works, the earliest in its origin was his General Idea of the Government and People of Indostan. It was principally written in 1752, and finished during his return to England in the next year. A part of it was prefixed to his Military History, and it is printed in its entire state among his posthumous works.

2. History of the Military Transactions of the British Nation in Indostan, from the year 1745. A Dissertation on the Mahommedan Conquests and Establishments in Indostan is prefixed to the first volume. "No historian," says the author of the Annual Register for 1764, "seems to have been more perfectly informed of the subject on which he has undertaken to write; and very few have possessed more fully the talent of impressing it, in the clearest and most vivid manner, on the imagination and understanding of his reader." The first volume, published in 1763, extends to 1756; and the second, published in 1778, carries the history down to the peace of 1763.

3. Historical Fragments of the Mogul Empire, from the year 1659, 8vo, London, 1782; first published anonymously, but acknowledged and reprinted in 4to in 1805; together with the Origin of the English Establishment at Broach and Surat, the General Idea of the Government and People of Indostan, and a Life of the Author. The Historical Fragments is a work of considerable research, making a sort of episode to the Military History, to which it affords some additions and corrections. It relates principally to the sanguinary Aurungzebe and his immediate successors, and to his contemporary, Sevagi the "Morattoe," the professed descendant of Porus. The Essay on the Trade of Surat is a fragment which was left unfinished by the author.

4. Several hundred volumes of Mr Orme's manuscript collections, together with some scarce printed tracts relating to oriental history, are carefully preserved in the library of the East India Company.

ORMEA, a city of the province of Mondovi, in the continental part of the kingdom of Sardinia, and situated on the river Tanaro. It is surrounded with old walls, and has a citadel, a collegiate church, and 800 ill-built houses, with 5460 inhabitants, who carry on an extensive trade in linens.

ORMOND, the northern division of the county of Tipperary, in the province of Munster, in Ireland. For a long time it gave the title of earl, and afterwards of marquis and duke, to the noble family of Butler, descended from a sister of St Thomas a Becket, archbishop of Canterbury; till, at the accession of George I. the last duke was attainted of high treason, and died abroad. In that part of the country the family had great prerogatives and privileges, which were granted by Edward III.

ORMSKIRK, a market-town of the hundred of West Derby, in the county of Lancaster, twelve miles from Liverpool, and 210 from London. The parish is very extensive, comprehending six townships and one chapelry. The town is well built, consisting of four streets crossing each other at right angles. Its church is a handsome Gothic structure, and is remarkable for having the tower and the steeple detached from each other, so as to appear like two churches. There is a good market on Thursday, and considerable trade at all times, arising from the navigable canals, to which there is easy access. The population of Ormskirk township amounted in 1801 to 2554, in 1811 to 3064, in 1821 to 3838, and in 1831 to 4251.

Ormuz.

ORMUZ, a barren island in the Persian Gulf, on which was formerly built a city, forming a vast emporium of Indian trade, and celebrated for its wealth and its extended commerce all over Asia. This island is about twelve miles in circumference, and resembles, when viewed from the sea, a mass of rocks and shells thrown up by some violent convulsion from the bottom of the ocean. Not more than 500 inhabitants are contained within the walls of the fort and a wretched suburb. A range of hills intersects the island from east to west, from the suburb to these heights is about a mile and a half, and the ground continues level about two miles along the northern shore. This whole space is one mass of ruins; and it is only where the reservoirs of water have been made that the buildings are in any thing like a perfect state. According to the account of Kinneir, these appear to have been made in the shape of a hollow cylinder, covered by an arch of solid masonry; and it is probable, he adds, that every house of consequence had one of these reservoirs, as there is only a record of one well of fresh water ever having been on the island, and that is now dry. The rocks of Ormuz consist almost entirely of fine crystal salt; and, from various specimens which are found on the surface, there can be little doubt of its abounding with sulphur and a variety of metals, especially iron and copper. It is mentioned that the southern part of the island is one entire heap of cliffs and rocks. These sink abruptly, towards its northern extremity, into a plain, comprising an extent of six or eight square miles of comparatively level country, terminating in a sandy spit that divides the harbour of Ormuz into two parts, and on which stands the old Portuguese fort. The harbour is tolerably good, being surrounded on all sides by the land, though the bottom affords good anchorage. The fort, which is still in a good state of repair, is built on a narrow neck of land jutting into the sea, by which the walls are washed on the northern and western sides, and was never of great extent or regular figure. The walls have been most carefully and substantially built of the rock afforded by the island. Strong bastions command each face, and the height from the water to the ramparts may be about eighty feet. The walls are in good repair, but the interior is in ruins. Two large reservoirs for supplying them with water still subsist, and both are covered in. The roof of one rests on two rows of massy pillars, and its diameter is about 100 feet. The fort was formerly separated from the mainland by a canal cut through the neck of land, and this was crossed by a drawbridge; but it is now chiefly filled up, the eastern part serving as a dock for repairing boats. A rotten plank is the only passage to the gateway, which is strongly defended by guns from the neck of the opposite bastion. Several iron and two brass guns are mounted on the walls, bearing the Portuguese arms. The carriages of the guns are so bad that they would not bear a single discharge. A mud wall, just beyond the old ditch, encloses between itself and the fort the few miserable huts that are occasionally tenanted on the island. "Beyond this," says Frazer, in his Narrative of a Journey through Khorassan (p. 47), "upon the plain extending to the feet of the mountains, lie scattered the ruins of the ancient Arabian and Portuguese city, with its villas and seats, which are constructed of such perishable materials that scarcely

Ormuz.

any relics of importance are to be seen." The only remarkable object is a tower near the wall, which Frazer conjectures to have been a minaret built by Shah Abbas after he had captured the place. Along the shore both of the eastern and western bays, not far from the water's edge, may be still seen a row of ruined houses, arcaded into apartments of various sizes and dimensions, which, in the opinion of Frazer, have been sirdabs or underground apartments for retiring to in warm weather, or cellars for receiving merchandise. The whole was of the same solid architecture as the first. The ground beyond, for a considerable space towards the mountains, was thickly strewed with broken tiles, pottery, glass, and the other usual destructible relics of an eastern city thrown into heaps of rubbish. Ormuz thus was possessed of no natural advantages, either from soil or climate; the heats during the summer being scarcely supportable by the human frame. It produces no articles of provision, not even a drop of water; so that it required a great exertion to render it habitable. The greater portion of the island consists of volcanic rocks, and the remainder of uneven stony places, strongly impregnated with salt; so that the means of improving the country do not exist. Not a tree nor a shrub can be raised; for the first necessary, water, is entirely wanting, and all vegetable supplies come from Kishmee or the mainland. Considering the barrenness of the island, Frazer doubts where the blooming and aromatic shrubs, that in former times were said to have decorated the streets, could have been found. The surface of the plain, though level when contrasted with the mountains beyond it, is still found extremely rugged on a nearer approach, and broken into ravines. The rocks are strongly impregnated with iron; they rise in rugged amorphous masses, strewing the ground with ruins, from which the mountains rise abruptly in bare desolate crags, and sharp, lofty peaks, of every variety of form and hue. "In many parts," says Frazer, "these, as well as the plains below, have a volcanic appearance, and a looseness of texture that alarms the traveller lest the surface should give way under his foot, and swallow him up in yet smoking ashes." The only products of Ormuz are iron in various shapes, sulphur; salt, which is produced from several salt springs, and is the only source of revenue in the island. The export in the company's ships is prohibited, lest it should interfere with the monopoly of salt in India. But the export to other places is considerable. The garrison of Ormuz consists of eighty soldiers belonging to the imaum of Muscat, who live immured in this desolate spot in great wretchedness. The broadsword and the target are their chief arms. These swords are sharp and thin, and previous to an attack they make them quiver and ring in the hand, with a jerk, whilst held in an upright position, and then charge with loud shouts. Ormuz was entirely indebted for its pre-eminent splendour to commerce, and it was long the great dépôt both of Indian and European produce. When the Portuguese fleet had found their way to India round the Cape of Good Hope, they soon cast a covetous eye on the wealth of Ormuz. They made several attempts to gain possession of it, but without effect, till in 1514 it surrendered to Albuquerque, who approached with an overwhelming force. It continued to be one of the chief seats of the Portuguese power till the reign of Shah Abbas, who conceived the plan of its conquest, and of attaching it as an appendage to the Persian empire. His attempt would have been vain had he not been aided by an English squadron which happened to be cruizing in these seas; and the commanders of which, being hostile to the Portuguese, readily fell in with the schemes of the Persian monarch. Their combined forces having landed, obliged the Portuguese to evacuate the town and to retire to the castle, which was at last reduced, chiefly by famine. Under the Persian regime the town decayed; the trade was ordered by the Shah to be transferred to Gombroon, on the opposite coast; and all the inhabitants at last followed, leaving only a Persian garrison. About the end of the last century Ormuz was taken possession of by the imaum of Muscat, and the inhabitants were then reduced to forty families. But the fort has since been repaired, and now contains 500 families. Long. 56. 40. E. Lat. 27. 8. N.

Orne ‖ Ornithiæ.

ORNE, a department of France, formed out of the southern part of the ancient province of Normandy and a portion of the division of Perche. It lies between north latitude 48. 12. and 48. 58., and in longitude between 1. 1. and 0. 50. west. It is bounded on the north by the departments of Calvados and Eure, on the east by Eure and Loire, on the south by Sarthe and Mayenne, and on the west by La Manche and the sea. It is 2524 square miles in extent, or, according to the Almanac Royale, 645,254 hectares, of which 318,750 are under the plough, 63,750 are meadows and pasture, 61,500 are woods, and the remainder is uncultivated, or the sites of towns, and the courses of rivers, or roads. It is divided into four arrondissements, thirty-five cantons, and 627 communes, and contains a population of 443,688 persons, who almost all adhere to the Roman Catholic church. The face of the country is hilly, though few of the elevations exceed 600 feet. The valleys between these hills are most abundantly supplied with streams of water, and it is said that no less than 300 rivers, great and small, have their sources within the department. As a whole, it thus appears to be a lofty region. The Orne, the Mayenne, and the Sarthe, are the great rivers by which the water of the smaller streams runs to the ocean. There are many morasses, ponds, and small lakes between the hills, but no canals. On the hills the soil is of a very sterile character, yielding only some scanty pasturage for cattle. In the valleys it is better, but much of it is either sandy or very stony. The climate is cold, but dry and healthy. In the spring, from the height of the land, the northerly winds often prove injurious to the blossoms of the fruit-trees, and even to the corn. The wheat, as well as the rye, is peculiarly subject to blight. The agriculture is badly conducted, although of late somewhat improved. It does not produce sufficient corn for a half year's consumption, and what is raised is of an indifferent quality. The country people are generally poor; they are clothed with coarse materials made by themselves, generally wear wooden shoes of their own fabrication, feed on buckwheat and rye, and for drink have bad cider or perry. No wine is produced within the department, nor is any beer brewed. The products of most value are hemp and flax, which grow of fine and long fibre, and the sale of them procures the requisite corn from the neighbourhood. The cattle also yield some of the means of subsistence. The breed of Norman horses is good, and the races have of late years been improved by crosses with some of greater power. Many young black cattle are bred, and many sheep, a few of which yield fine wool. The forests have been neglected, and fuel is scarce. There are mines of iron, from which about 150,000 quintals of wrought and of cast iron are yearly produced, and mostly converted into nails and other ironmongery goods. There are some fine linens made, and much pillow-lace is made by the females, with thread spun from their own flax. Those articles made from flax are the most valuable products of manufacturing industry. A few cotton goods are also made; and some leather, paper, wax, honey, and bacon, may be added to the list of products. The city of Alençon is the capital of the department, which elects four deputies to the legislative chamber.

ORNITHIÆ, a name given by the ancients to certain winds, which usually set in during the spring, at the time when the birds of passage came over to them.

ORNITHOLOGY.

History. ORNITHOLOGY, from ὄρνις, *bird*, and λόγος, *discourse*, is that department of Zoology which treats of the history and attributes of the feathered race. Birds form the second great division of the animal kingdom, being usually placed immediately after the Mammalia, and antecedent to the reptile class. They may be defined as vertebrated, oviparous animals, covered with feathers, organized for flight, and enjoying a double system of circulation and respiration; that is, their whole blood, like that of quadrupeds, must visit the lungs and return to the heart before it is propelled to the extremities,—and the entire system is provided with reservoirs of air, in addition to the lungs properly so called.

The vast extent which the science of Ornithology has acquired in recent times renders a full exposition impossible within our necessarily prescribed limits; but we shall endeavour at least to indicate the majority of the more important groups, to figure and describe in each some interesting species, and by frequent reference to such authors as have most successfully treated of the different branches in detail, enable such of our readers as desire a more elaborate view, to follow out the subject for themselves. We presume it matters not with which department we commence. Let us begin, then, with the Bibliography, which, however, need not detain us long.

Few if any important works have been transmitted to us from antiquity. In the third book of Aristotle's History of Animals (Περι Ζωων Ἱστορια, the period being about 350 years before the Christian era) we find recorded sundry observations, but brief and superficial, on the feathered race.[1] His division seems to be into such as have hooked claws, such as have separated toes, and such as are web-footed; and he observes, that the first have the breast the most robust. He describes the differences in the structure of the feet, and notices, that although the generality have three toes in front, and one behind, yet a few have only two toes in front. The bill supplies the place of lips and teeth, and passages in different parts of the head supply the place of the external organs of the senses of smell and sound. The eyes are furnished with a membrane like that possessed by lizards, but want eyelashes. No bird with hooked claws has likewise spurs upon its legs. These are a few examples of Aristotle's style of observation on the class in question.

Pliny was born about the twentieth year of the Christian era. The tenth book of his *Historia Naturalis* treats in part of birds, but in a very meagre and immethodical manner. He tells us of the raven and the phœnix, of the owl, the ibis, and the nightingale, of capons, and the cock-fights of Pergamus, and of the character and conduct of various other birds.

For 1500 years from the time of Pliny we have no recorded observations on Ornithology deserving of the reader's recollection. About the middle of the 16th century Conrad Gesner, a native of Zurich, and a noted Frenchman called Pierre Belon, each published works in part devoted to Ornithology. The writings of Gesner (*Historia Animalium*, 3 vols. folio) exhibit a cumbrous erudition, with a sprinkling of original observation, but are chiefly extracted from ancient authors. Baron Cuvier regarded him as an excellent compiler. His arrangement is alphabetical. Belon's most successful efforts were in the ichthyological department, but even in his *Historia Avium*, History. 1 vol. folio, 1551, we may trace an improved spirit of observation, although the basis of his classification would scarcely suffice to support a system now-a-days. He divides the class of birds into six primary divisions. 1*st*, The birds of prey, among which, misled probably by some false analogy of plumage, he includes the cuckoo. 2*d*, The Palmipedes. 3*d*, The Grallæ, including, however, the king-fisher, bee-eater, and other anomalous species. 4*th*, All the species which place their nests upon the ground, —an extraordinary bond of union, which of course brings together the pheasant, the lark, and the woodcock. Nevertheless, our author does not confound them in his lesser groups. 5*th*, The omnivorous and insectivorous birds, among which are placed the pigeons. 6*th*, The insectivorous and granivorous species, which habitually frequent shrubs and hedges.

Another noted writer of the sixteenth century was Ulysses Aldrovandi of Bologna, whose works amount to thirteen volumes folio;—the majority of them, however, were not published till after his death in 1606. The first three, which treat of birds (as well as one on insects), made their appearance in his lifetime, that is, from 1599 to 1603. They contain some amusing information, amid a vast mass of learned rubbish borrowed from his predecessors. Professor Savi, however, characterised the ornithological portion as "un monumento glorioso del suo instancabile zelo, delle sue estese cognizioni ornithologiche, e della sua universale erudizione." It is at the same time entirely deficient in scientific precision, and contains, amid much truth, a sad intermixture of unmeaning fable. The edition with which we are best acquainted is that of Bologna, 1634.

About nearly the same period a treatise was published by Gommer de Luzaney, with the title of *De l'Autourserie*, which contains some good figures of the birds of prey used in falconry. One of the earliest sketches of the history of European birds is that given by Schwenkfeld, a Prussian naturalist, in a volume entitled *Theorio-Tropheum Silesiæ*, 1603. The arrangement is alphabetical. Olina's *Uccelliera*, which contains tolerable figures of a few species not previously published, appeared at Rome in 1622. It is a small affair, restricted to the description of very few species, but contains accurate and interesting records of their history and mode of capture, as practised by the Italians, with whom *la caccia*, very different from that of Melton Moubray, is a noted passion. A swarthy, fire-eyed hunter of sixty-five is as proud of a string of dead linnets as any young Scotchman of sixteen may be of his first well-filled bag of grouse or black game.

We have next a dissertation on storks, cranes, and swallows, by J. G. Swalbacius (Spire, 1630); a natural history of Nurenberg (Antwerp, 1633); a description of the birds of the West Indies, by De Laet (Leyden, same year); a history of the birds of Brazil, by Marcgraaff (in his *Hist. Rerum Nat. Brasiliæ*, Amsterdam, 1648); and of those of Mexico, by Hernandez (in his *Nova Plant. Animal. et Min. Mexicanorum Hist.* Rome, 1651). A Scoto-Pole of the name of Johnston published about this period (some years elapsing during the completion of the various parts) his *Historia Animalium*, of which the second portion treats of birds. He is a follower, not so much of nature, as of Belon, and other authors of the pre-

[1] As in some of our preceding treatises on Natural History in this work (see, for example, the article MAMMALIA, vol. xiv. p. 74) we have entered at greater length into the general character of the most ancient writers, our present notices are therefore extremely slight.

History. ceding century, and was himself followed by Ruysch, whose *Theatrum Universale Animalium Omnium* may be regarded as a second edition of Johnston's work. The *Natural and Medical History of the East Indies*, by Bontius, appeared in 1658, and contained descriptions of various birds at that time new. Soon afterwards Perrault, Borrichius, and Bartolinus, began to furnish the earliest modern contributions to the *anatomy* of the feathered race.

Willughby's *Ornithologia* (a posthumous work, believed to have been greatly amended and increased by Ray) was published in 1676. The first edition is in Latin, but an English translation, enlarged, made its appearance two years after. Ray's own *Synopsis Methodica Avium* (*et Piscium*) was likewise published posthumously, under the care of Dr Derham, in 1713. The writings of these authors are remarkable, as manifesting an approach to a more natural system of arrangement than had hitherto prevailed; but as they have been so frequently analysed, we deem it unnecessary to occupy our space with any detailed exposition of their views. Baron Cuvier has termed Ray "le premier véritable méthodiste pour le règne animal, guide principal de Linnæus dans cette partie." In Sir Hans Sloane's *Voyage to Jamaica*, &c. (1707–25), we have notices of various birds, accompanied by rather poor engravings; but the work was of great use to science in England, by the attention and emulation which it excited in regard to natural objects, of which the author had brought together upwards of 36,000, besides 200 volumes of preserved plants. His collections formed the original basis of the British Museum. A showy but inaccurate work by Marsilli (1726) is devoted to an interesting subject, the birds of the banks of the Danube. Albin's *Natural History of Birds*, in 3 vols. 4to (1731–38), contains above three hundred coloured figures of no great merit. Yet it was afterwards reprinted in French, with additions, at the Hague. About the same period was published Catesby's *Natural History of Carolina, Florida, and the Bahama Islands*, in 2 vols. folio, and appendix (1731–43), with numerous coloured plates of birds and other beings. Frisch's excellent work on German birds (*Vorstellung der Vogel Deutschlands*) was commenced at Berlin in 1734, and was not completed when the author died. It was continued by a stranger, and a collected edition of the whole work, with two hundred and fifty-five plates, was published in 1763. Although by no means highly finished, these engravings are accurate, and exhibit a good deal of the truth of nature. The arrangement is defective, and retrogrades from that of Ray. Seba's great, or rather large work, the *Locupletissimi rerum naturalium Thesauri accurata descriptio*, was being carried on during this period at Amsterdam, in four volumes folio (1734–65). It is unworthy of being quoted, except in reference to the plates.

By this time the illustrious reformer of systematic natural history had made his appearance as an author; the first edition of the *Systema Naturæ*, consisting of only fourteen pages folio, having been published at Leyden in 1735, when Linnæus was not more than eighteen years of age. It ran through twelve editions in little more than thirty years; the twelfth impression, the last which the author could himself revise, appearing at Stockholm in 1766–68. The influence exercised by the writings of the great Swedish naturalist is too important to admit of our proceeding farther without exhibiting a view of his classification, so far at least as concerns the feathered race. The following table presents an outline of the Linnæan arrangement of birds, which he divides into six primary groups called orders.

Order I. Accipitres, or *birds of prey*. The bill more or less curved, the upper mandible dilated, or armed with a tooth-like process near the tip; the feet short, robust, with acute hooked claws. History.

Genus *Vultur*. Vultures. Beak hooked; head bare: eight species.

Falco. Eagles and hawks. Beak hooked; head feathered: thirty-two species.

Strix. Owls. Beak hooked, feathers at its base directed forwards: twelve species.

Lanius. Shrikes. Beak straightish, notched: twenty-six species.

Order II. Picæ. The bill cultriform, with the back convex; the feet short, rather strong.

Genus *Psittacus*. Parrots. Beak hooked; upper mandible furnished with a cere: forty-seven species.

Rhamphastos. Toucans. Beak very large, hollow, convex, serrated; both mandibles incurved at the tip: eight species.

Buceros. Hornbills. Beak convex, curved, cultrate, large, serrated; forehead covered by a horny plate: four species.

Buphaga. Beef-eaters. Beak straight, somewhat quadrangular; the mandibles bulging: one species.

Crotophaga. Plantain-eaters. Beak compressed, half egg-shaped, arched, keeled on the back: two species.

Corvus. Crows. Beak convex, cultrate; nostrils covered by recumbent bristly feathers: nineteen species.

Coracias. Rollers. Beak conical, convex, straight, acute; upper mandible slightly longer, and indistinctly notched: twenty species.

Gracula. Grakles. Beak cultrate, convex, somewhat bare at the base: eight species.

Paradisea. Birds of Paradise. Beak covered with the downy feathers of the forehead; feathers of the sides long: three species.

Trogon. Curucuis. Beak shorter than the head, cultrate, hooked, serrated: three species.

Bucco. Barbets. Beak cultrate, laterally compressed, notched at the tip, incurved, opening to beneath the eyes: one species.

Cuculus. Cuckoos. Beak roundish; nostrils with a prominent margin: twenty-two species.

Yunx. Wrynecks. Beak roundish, sharp pointed; nostrils concave: one species.

Picus. Woodpeckers. Beak angular, straight, the tip wedge-shaped; the nostrils covered with recumbent bristly feathers: twenty-one species.

Sitta. Nut-hatches. Beak awl-shaped, roundish, straight: three species.

Todus. Todus. Beak awl-shaped, a little flattened, obtuse, straight, with spreading bristles at the base: two species.

Alcedo. King-fishers. Beak three-cornered, thick, straight, long: fifteen species.

Merops. Bee-eater. Beak curved, compressed, keeled: seven species.

Upupa. Hoopoes. Beak arcuate, convex, a little compressed, rather obtuse: three species.

Certhia. Creepers. Beak arcuate, slender, acute: twenty-five species.

Trochilus. Humming-birds. Beak slender, longer than the head, its tip tubular: twenty-two species.

Order III. Anseres. Web-footed water-fowl. Bill smooth, covered with epidermis, enlarged at the tip; the toes united by a web, the legs compressed and short.

Genus *Anas*. Swans, geese, ducks. Beak lamellated at the margin, convex, obtuse: forty-five species.

History.

Genus *Mergus.* Mergansers. Beak denticular cylindrical, the tip hooked: six species.

Alca. Auks. Beak short, compressed, convex, furrowed, the lower mandible with a prominent angle: five species.

Procellaria. Petrels. Beak a little compressed; the upper mandible hooked, the lower channelled and compressed at the tip: six species.

Diomedea. Albatrosses. Beak straight; upper mandible hooked at the tip, lower abrupt: two species.

Pelecanus. Pelicans, solan-geese, cormorants. Beak straight, the tip hooked, unguiculate: eight species.

Plotus. Darters. Beak straight, sharp-pointed, denticulate: one species.

Phaeton. Tropic birds. Beak cultrate, straight, acuminate: two species.

Colymbus. Divers. Beak slender, straight, sharp-pointed: eleven species.

Larus. Gull. Beak straight, cultrate, the tip slightly hooked, the lower mandible with an angular prominence: eleven species.

Sterna. Terns or sea-swallows. Beak slender, nearly straight, acute, compressed: seven species.

Rynchops. Skimmers. Beak straight; upper mandible much shorter, lower abruptly terminated: two species.

ORDER IV. GRALLÆ. *Waders or shore-birds.* Bill somewhat cylindrical; the feet long, bare above the tarsus, and formed for wading.

Genus *Phœnicopterus.* Flamingoes. Beak incurvated as if broken, denticulate; feet webbed: one species.

Platalea. Spoon-bills. Beak flattish, the tip dilated, rounded, and flat: three species.

Palamedea. Screamers. Beak conical; the upper mandible hooked: two species.

Mycteria. Jabiru. Beak acute; lower mandible trigonal, ascending; upper three-cornered, straight: one species.

Cancroma. Boat-bills. Beak bulging; the upper mandible resembling a boat with the keel uppermost: two species.

Ardea. Herons and cranes. Beak straight, acute, long, a little compressed, with a furrow from the nostrils to the tip: twenty-six species.

Tantalus. Ibis. Beak long, slender, arcuate; face bare: seven species.

Scolopax. Snipes and curlews. Beak long, slender, obtuse; face feathered: eighteen species.

Tringa. Sand-pipers, or shore-larks. Beak roundish, as long as the head; nostrils linear; feet with four toes: twenty-three species.

Charadrius. Plovers. Beak roundish, obtuse; feet with three toes; twelve species.

Recurvirostra. Avosets. Beak slender, recurved, pointed, the tip flexible: one species.

Hæmatopus. Oyster-catchers. Beak compressed, the tip wedge-shaped: one species.

Fulica. Coots. Beak convex; upper mandible arched over the lower, which has a prominent angle: seven species.

Parra. Jacanas. Beak roundish, rather blunt; forehead wattled; wings spurred: five species.

Rallus. Rails. Beak thicker at the base, compressed, acute: ten species.

Psophia. Trumpeter. Beak conical, convex, rather sharp; the upper mandible longer: one species.

Otis. Bustards. Beak with the upper mandible arched: four species.

Struthio. Ostrich and cassuary. Beak somewhat conical; wings unfit for flying: three species.

ORDER V. GALLINÆ. *Poultry* and other *gallinaceous birds.* Bill convex, the upper mandible arched over the lower, the nostrils arched with a cartilaginous membrane. Feet with the toes separated, and rough beneath. History.

Genus *Didus.* Beak contracted in the middle, with two transverse rugæ; the tip of both mandibles bent inwards: one species, now extinct.

Pavo. Pea-fowl. Head covered with feathers, those of the rump elongated, with eye-like spots: three species.

Meleagris. Turkeys. Head covered with spongy caruncles; the throat with a longitudinal membranous wattle: three species.

Crax. Curassoes. Beak with a cere at the base; head covered with recurved feathers: five species.

Phasianus. Domestic fowls and pheasants. Sides of the head bare: six species.

Numida. Guinea-fowls. Carunculated wattles on each side of the face; head with a horny crest: one species.

Tetrao. Grouse and partridges. Bare papillæ near the eyes: twenty species.

ORDER VI. PASSERES. *Passerine birds, and others.* Bill conical, sharp pointed; feet slender, the toes separated.

Genus *Columba.* Pigeons. Beak straight; nostrils with a tumid membrane: forty species.

Alauda. Larks. Beak slender, pointed; tongue slit; hind claws very long: eleven species.

Sturnus. Starlings. Beak slender, pointed; flattened towards the point: five species.

Turdus. Thrushes. Beak subulate, compressed, notched: seven species.

Ampelis. Chatterers. Beak awl-shaped, depressed at the base, notched: seven species.

Loxia. Gross-beaks, bullfinches, &c. Beak conical, bulging at the base: forty-eight species.

Emberiza. Bunting. Beak somewhat conical; lower mandible broader: twenty-four species.

Tanagra. Tanager. Beak notched, awl-shaped, conical at the base: twenty-one species.

Motacilla. Wagtails and warblers. Beak awl-shaped; tongue jagged; claw of the hind toe of moderate length: forty-nine species.

Pipra. Manakin. Beak awl-shaped, feathers at its base directed forwards; tongue abrupt: fourteen species.

Hirundo. Swallows. Beak very small, depressed at the base, incurved; the mouth wider than the head: twelve species.

Caprimulgus. Goat-suckers. Beak very small, incurved, depressed at the base; large bristles; the mouth very wide: two species.

The amount of species in the class of birds with which Linnæus had to form his system did not greatly exceed *nine hundred.* Yet with what admirable tact has he seized upon the characteristic forms which so long served as the nuclei around which so many other species were assembled! It is true that his arrangement, like all other inventions of human genius, is liable to many objections, and may not suit the subject in the wide extent acquired in recent times;—but when we see how closely his ordinal divisions accord even with the most elaborate arrangements of modern days, and how gracefully his generic groups may now be formed into more extended families, each retaining such strong affinities in its constituent parts, we the more incline to marvel at the two following circumstances;—1*st*, That Linnæus himself should have so far advanced before his age, and anticipated the labours of posterity: 2*d*, that that posterity, or such portion of the same as in-

History. cline not seldom to sneer at his unprecedented and even now unequalled labours, should not perceive that it is to his system they are indebted for almost all that is of any value in their own. But on this subject we shall not here enlarge.

It has been sometimes remarked, that the characters given by Linnæus to his orders are totally inapplicable to many of the species which each contains. Thus the vultures, it is said, which belong to the first order, have no projecting processes on the upper mandible; the parrots, which are referred to the second, have the bill hooked, not cultriform, and bear no resemblance to the other species; among the Anseres, which are characterised as having the bill smooth, covered with epidermis, and enlarged at the tip, are the gannets, with a bare and pointed bill, and the divers, terns, and gulls, with bills not at all answering to the description given; among the Grallæ, with a cylindrical bill, are the ostrich, with a short depressed one, the canchroma, with one resembling a boat, the spoon-bill, the heron, the flamingo, and others, the bills of which differ from each other as much as from those of the snipes and curlews; the character given to the bill of the Gallinæ agrees with that of many Passeres; and the wag-tail, the swallow, the tit-mouse, the red-breast, and numerous other small birds, have bills very different from those of the gold-finch, bunting, bullfinch, and cross-bill, which, nevertheless, are all defined under the same order, and by a similar phrase.[1] We believe the truth to be, that the more natural an order is, the greater the difficulty becomes of expressing its characters in a single line, in accordance with the briefness of the Linnæan method,—because none of these characters, taken in disconnection, remain unmodified throughout the extended series of beings which they are intended to define. There is always a blending or transition towards other groups, so that the character expressed in words must be regarded as applying in force rather to certain species which exemplify the whole, and towards which the others *tend*, than to the entire assemblage. Now the Linnæan genera are often natural as family groups, though their constituent portions may not accord with the definition; and as they become extended, or rather filled up, by the discovery of new species, the difficulty increases. Many of the modifying species, or connecting links, were totally unknown in the time of the great Swedish observer, who seized chiefly upon the more prominent and tangible points; and the necessity of forming new subdivisions in no way invalidates his claims upon the gratitude of all lovers of the *lucidus ordo*. At the same time his early disciples erred (though less grossly than many of the later renegades) in viewing all living things as merely destined to clothe with flesh and blood the gigantic frame-work which he had erected,—as if his exposition of the system of nature were in fact itself that system,—as if the highest attainments of any one, however gifted, in either art or science, were ever more than the passionate expression of some dim vision of truth, perceived through the influence of the love of knowledge. With all the lights of modern method, and the vaunted improvements in classification, see we not still "through a glass darkly?" Have not some of those who talk slightingly of the Swedish sage never contrived to see through the glass at all?

During the thirty years which elapsed between the first and twelfth editions of the *Systema Naturæ*, several important additions were made to Ornithology from other quarters. Edwards, especially, in his *Natural History of Birds, and other rare undescribed Animals*, and in his *Gleanings in Natural History*, amounting in all to seven volumes 4to (1743 and after years), made known in a rough but recognisable style, many new and interesting species. "C'est le recueil," says Cuvier, "le plus riche pour les oiseaux après les planches enluminées de Buffon." During the same period a letter was published at Pappenheim, on the birds of the Black Forest, by J. H. Zorn, *Epistola de Avibus Germaniæ, præsertim Sylvæ Hercyniæ*, which contains many excellent observations; and the correspondence was afterwards extended by Brückmann in his *Aves in Germania obviæ Epistolar. Itinerar.* cent. ii. epist. 18, and *Aves Sylvæ Hercyniæ*, ibid. epist. 17. In Anderson's *Natural History of Iceland and Greenland* (1750), we have among the earliest authentic notices of the Zoology of these northern regions. Klein and Maering each published systematic works, but based on very artificial principles, at this epoch. In Brown's *Civil and Natural History of Jamaica*, there are several ornithological contributions; and we may here name another excellent English work, Borlase's *Natural History of Cornwall*, which appeared at Oxford in 1758. In 1760 Brisson published his great systematic *Ornithologie*, in six volumes 4to, still of value for the minute though laborious exactness of the descriptions. His method is founded entirely on the form of the bill and feet, the number of the toes, and the manner in which these are united, with or without membrane, to each other. The *Ornithologia Borealis* of Brunnich appeared at Copenhagen in 1764.

The *Storia Naturale degli Uccelli*, printed at Florence in 1767, is the most extensive of all the Italian works on Ornithology, after that of Aldrovandi. It is frequently named by Temminck and other modern writers, most of whom, however, from their vague references, may be safely inferred to quote at second hand. It consists of a large collection of plates both of indigenous and exotic birds, executed with sufficient exactness, considering the slight practice which obtained in those days in the representation of natural objects. The position of most of the figures, as Signor Savi remarks, is forced and unnatural; and we may see at once that the artist was guided more by his own fancies than the accustomed observance of living nature. "Illuminatio non semper optima, nec optimus semper avium situs," are the observations made by Bœhmer.[2] The plates were engraved from drawings in the collection of a Florentine patrician, the Marchese Giovanni Gerini, a passionate lover of Ornithology, who passed much of his time in collecting, and causing to be described and figured, whatever birds he could procure from every clime and country. After his death some learned men, unfortunately not much skilled in Ornithology, supposing either that general erudition might suffice for science, or that the superficial study of a few books might compensate the want of laborious observations carried on from year to year, undertook to publish Gerini's uncompleted work, to fill up the voids which he had left, and even to alter what he had already done. They thus compiled a superficial text, in which they confused the classification, mistook the species, omitted several of the most interesting, and neglected the localities,—so that a work which, in the hands of an able editor, might have added a new glory to the already illustrious literature of Italy, became nothing more than a disorderly collection of figures. It is, however, of some value, chiefly as containing representations of species not previously known, such as *Falco cenchris*, *Fringilla cisalpina*, *Sylvia provincialis*, *melanocephala*, and *melanopogon*, *Sterna leucoptera*, &c.

From the year 1767 onwards, Pallas, in his *Spicilegia Zoologica*, the narrative of his various *Travels*, and the *Acta* of the Royal Academy of St Petersburg, contributed to Ornithology, as to most other branches of zoological science;

[1] Macgillivray's *Lives of Zoologists*, vol. i. p. 279.

[2] *Bibliotheca Scriptorum Historiæ Naturalis*, &c. tom. iii. p. 502.

History. and about the same time the industrious Pennant was actively engaged in his important labours. His numerous well-known works need not be here particularised. The great collection published at Nuremberg by Schligmann in 1768, though amounting to nine volumes folio, including an indifferent text, seems chiefly copied from preceding works, such as those of Catesby and Edwards. In 1770 and following years, Noseman, in conjunction with Sepp the engraver, published, in Dutch, his *History of the Birds of the Low Countries*. The concluding fasciculi are by Houttuyn. Baron Cuvier thinks the figures "remarkable for their elegance." Mr Swainson regards them as "poor and unnatural." The year 1770 is farther marked as an important epoch, by the appearance of the first two volumes of the *Histoire Naturelle des Oiseaux*, by Buffon. That illustrious writer was the first to clothe the descriptive portion of the science with colours as bright and varied as those which beautify the fairy forms of which he treats, but which had hitherto been viewed as it were only by the half-closed eye of the technical describer. The *Planches Enluminées*, afterwards published by Daubenton the younger, in illustration of Buffon's work, amount to above a thousand plates of birds, being the greatest and most important collection yet achieved in this department. In 1774 we have the *Elementa Ornithologica*, by Schœffer, whose system rests entirely on the legs and feet of birds, the primary sections being divided into *nudipedes* and *plumipedes*, while the orders and genera are determined by the number, position, and connection of the toes. He never employs the bill when he can help it; from which we may infer the nature of the work, and its probable utility to the student.

The *Voyages aux Indes*, &c. by Sonnerat (1775 and succeeding years), contains figures and descriptions of many new exotic species. Scopoli's *Introductio ad Historiam Naturalem*, published at Prague in 1777, exhibits a systematic distribution of birds, based on the form of the scales which cover the tarsi. Thus the species which, like the generality of the accipitrine kinds, parrots, the gallinæ, grallæ, and palmipedes, have those parts covered by small polygonal scales, form the section called *retepedes;* while the others, which have the tarsi protected in front by semicircular plates, bordered behind on each side by a longitudinal furrow, constitute the *scutipedes*. The general result, however, of this view is by no means successful. In 1776 Francesco Cetti published his *Uccelli di Sardigna*, a small octavo volume, containing descriptions of only a portion of the Sardinian birds, but valuable, from its notices of their habits, and the description of various new species.

Latham's *General Synopsis* commenced in 1781. However faulty in relation to the present state of the science, it was a work of great merit for its time, and contains, under not very appropriate names, by no means inaccurate descriptions of many rare birds, some of which have since been published, by more recent writers, as entirely new. Under this head we may mention both the *Index Ornithologicus* of the same author (1790), and his greatly enlarged and more modern work, the *General History of Birds*, ten volumes 4to, 1821–24, which combines the two preceding (with their supplements); but is, we regret to say, a mere combination of those rather obsolete materials, without critical discrimination, or any correction of the ancient errors. There is great increase without much progression. Nearly contemporaneous with Latham's first work, we find contributions to Ornithology by Gilius, Merrhem, and Jacquin. About 1783 Mauduit commenced the Ornithology of the *Encyclopédie Méthodique*, for which Bonnaterre formed the system of classification which accompanies the volume of indifferent plates. Of the descriptive portion an excellent modern continuation, if not completion, has been published by M. Vieillot, in three volumes 4to, 1823. Sparmann, a pupil of Linnæus, and a well-known traveller, published in 1786 the *Museum Carlsonianum*, in which several new species are represented and described. In 1787 R. L. Desfontaines (in the *Mémoires de l'Académie des Sciences*) contributed some notices of birds which frequent the coasts of Barbary; and, in the same year, Martinet, who had acted under the younger Daubenton as a superintendent of the *Planches Enluminées*, took it into his head to publish, on his own account, a collection of figures and descriptions of birds, amounting to no less than nine volumes octavo. Their number was not more alarming than their nature.

In 1789 and following years, J. F. Gmelin published the thirteenth edition of the *Systema Naturæ* of Linnæus. "Son travail," says Baron Cuvier, "tout indigeste et dénué de critique et de connaissance des choses, est cependant nécessaire, comme la seule table un peu complète de ce qui à été fait jusque vers 1790." About a volume and a half is devoted to Ornithology. White's *Journal of a Voyage to New South Wales* appeared in 1790, forming an interesting addition to the natural history of a country which still offers a vast field for zoological research; and soon afterwards Shaw announced his *Zoology of New Holland*, which advanced no farther than a few fasciculi. We have likewise in 1790 the *Fauna Gröenlandica* of Otho Fabricius, a work of great merit for the time, and still holding a high place in the estimation of the naturalist, from the accuracy of its descriptions, although in some instances the names are misapplied. In 1792 M. Beseke published in German his materials for the *Natural History of the Birds of Courland*. The works by Lord, Hayes, Lewin, and others, which appeared about this epoch, in illustration of the birds of Great Britain, were so soon afterwards superseded by the admirable and unequalled wood engravings by the inimitable Bewick, that it is scarcely necessary to bring their names to the reader's recollection. We may close our imperfect sketch of the Ornithology of the eighteenth century by the mention of Cuvier's first work, the *Tableau Elémentaire d'Histoire Naturelle* (1798), which contains the methodical distribution of birds, which he afterwards completed in his *Règne Animal*.

We may commence the present century with the title of Daudin's work, the *Traité Elémentaire et complet d'Ornithologie*, two vols. 4to, 1800. It is an unfinished compilation, of no great merit, containing only the accipitrine birds, and a portion of the Passeres. Although Le Vaillant commenced his magnificent series of ornithological illustrations during the preceding season, and continued them at intervals for several years, we shall here group together the most important, for the convenience of the reader: 1st, *Histoire Naturelle des Oiseaux de l'Afrique*, six vols. 4to, 1799–1800. The plates amount to 300, but are inferior to those of the other works of the same author. 2d, *Histoire Naturelle d'une Partie d'Oiseaux Nouveaux et Rares de l'Amérique et des Indes*, one volume 4to, 1801. This volume illustrates the *Buceridæ* or horn-bills, and the *Ampelidæ* or fruit-eaters. 3d, *Histoire Naturelle des Perroquets*, 2 vols. 4to, 1801–5. Almost all the plates (139 in number) of this exquisite work are from drawings by Barrabaud, an almost unrivalled artist in the ornithological department. 4th, *Histoire Naturelle des Oiseaux de Paradis, et des Rolliers, suivie de celle des Toucans et des Barbus*, 2 vols. folio, 1806. "Equally splendid," says Mr Swainson, "with the preceding. The size and extraordinary plumage of the paradise birds require a scale fully equal to the dimensions of this volume, which exceeds any other of the author's in the beauty and splendour of its contents." We believe that the two volumes, though generally regarded as one series, were published separately, with distinct titles. 5th, *Histoire Naturelle des Promerops, et des Guépiers*, 1 vol. folio, 1807. This rare and beautiful volume

History. sometimes occurs alone, sometimes as forming volume third of the preceding series. A complete collection of Le Vaillant's works forms of itself a noble *gallery* of ornithological portraits. The letter-press, more especially that of the *Oiseaux d'Afrique*, is also of great value, and will be studied with additional advantage by those familiar with the delightful narrative of his first and second Travels into the Interior of Africa, 1790–95.

As belonging to the same class of works, and also of excellent execution, may be mentioned Desmaret's *Histoire Naturelle des Tangaras, des Manakins, et des Todiers*, 1 vol. folio, 1805. M. Vieillot, who died in 1828, after a very active career in Ornithology, is the author of the following works, all of a sumptuous character, and of considerable value in their way, though inferior in beauty to those of the two preceding authors. *Histoire Naturelle des plus beaux Oiseaux Chanteurs de la Zone Torride*, 1 vol. folio, 1805;—*Histoire Naturelle des Oiseaux de l'Amérique Septentrionale*, 2 vols. folio, 1807;—*Galerie des Oiseaux*, 4 vols. 4to, 1826, an extensive series of figures, chiefly from the collection of the museum in the Garden of Plants. M. Vieillot is likewise the continuator of Audebert's *Histoire des Oiseaux dorés, ou à reflets métalliques* (2 vols. folio, commenced in 1802); and has written largely on systematic Ornithology in the *Encyclopédie Méthodique (Ornithologie*, by the Abbé Bonnaterre, continued by M. Vieillot, 3 vols. 4to, besides the plates, Paris, 1823); and in the *Nouveau Dictionnaire d'Histoire Naturelle.* Lastly, he indicated various new groups, or at least a variety of groups under new names, in his *Analyse d'une Nouvelle Ornithologie Elémentaire*, Paris, 1816; a work which seems to have occasioned great offence to M. Temminck,[1] and some dissatisfaction to Baron Cuvier.[2]

Alexander Wilson's admirable *American Ornithology, or Natural History of the Birds of the United States*, was published in nine volumes quarto (including Mr Ord's Supplement) between 1808–14. It still maintains its character as a work of the highest value, and although it has been since surpassed by other works in elegance of design and beauty of colouring, its descriptive or narrative portion has been scarcely equalled. Of this most remarkable production several editions have been published in America, and two in this country, viz. one by Professor Jameson, in a cheap and commodious form (four small volumes of Constable's *Miscellany*, No. 68—71, 1831), with the advantage of a systematic arrangement of the original materials,—another by Sir William Jardine (in three large 8vo volumes, 1832), with plates, and consequently of higher price, but enriched by numerous notes of great value.

We may here name the *General Zoology*, in fourteen volumes octavo, 1800–26, commenced by Dr Shaw, and concluded by Mr Stephens. The last seven volumes are devoted to Ornithology. Most of the plates are copies. Illiger's excellent *Prodromus Mammalium et Avium* was published at Berlin in one volume octavo, 1811. It establishes several new and important genera.

The first edition of the *Règne Animal* of Baron Cuvier (four vols. 8vo) appeared in 1817; the second (in five vols. 8vo) was published in 1829. We need say nothing of the surpassing excellence of a work which cast the whole subject of Zoology into a new and more natural form, nor of the unequalled labours of the illustrious author, by whom the structure and characters of so many important groups have been brought from darkness into light. The general features of his system have, with few exceptions, been steadily adhered to throughout the zoological treatises of this Encyclopædia, and (which is more to be admired) do equally pervade and illumine the labours of many modern authors who yet place themselves in opposition to his doctrines, and seem to have forgotten, or been blinded by, the dazzling source from which they drew their "golden light;" as if the false though gorgeous glory of a cloud could of itself adorn the beauty of the azure heavens,—as if the reflection of a sparkling river were any thing more than the borrowed lustre of the "Great Apollo." Let the reader rest assured, that however praise-worthy may be the skill and devotedness of our ingenious system-makers, or however valuable may be the materials which they have brought to bear upon isolated portions of nature's most majestic kingdom, they are yet separated, by the will of God, in head and hand, "longissimo intervallo," from their great master. This is no reason, but the reverse, for their ceasing to exercise their useful talents and natural powers of observation with assiduity and patience, as becomes alike the aspiring philosopher and the humble Christian;—but let no man mistake "the spirit he is of," nor suppose an owl an eagle, seeing that not in every acceptation of the phrase is it true, that "a living dog is better than a dead lion." History.

The natural history of the birds of Germany has been amply and successfully illustrated by the well-known works of Naumann (father and son), by those of Bechstein, and of Messrs Meyer and Wolf. We owe to M. Leisler a Supplement to the work of Bechstein (Hanau, 1812–13), and of Naumann's *Naturgeschichte der Vogel Deutschlands*, a second edition (in octavo), with beautifully coloured plates, was commenced in 1820, but has not yet attained completion. Meyer and Wolf's *Taschenbuch der Deutschen Vogelkunde* now amounts to three volumes, and is filled with excellent observations, while their large illustrated work on German birds, commenced so far back as 1804, and recently brought to a conclusion, is one of the most beautiful with which we are acquainted. M. Brehm published his *Beitrage zur Deutschen Vogelkunde* in 1820–22, in three large volumes, filled with minute details, which exhibit an accurate practical knowledge of the science. The author's views of species are peculiar. His *Lehrbuch der Naturgeschichte aller Europaischen Vogel* (two volumes) was published in the following year. In this, too, he surely describes local races, or accidental varieties, as distinct species. To M. Brehm we likewise owe several fasciculi of a work commenced in 1824, and published at intervals, under the title of *Ornis.* It consists of memoirs and memoranda, by various authors, relating chiefly to Ornithology. Lastly, we may here name his *Handbuch der Naturgeschichte aller Vogel Deutschlands* (Ilmenau, 1831), forming a goodly volume of 1100 pages octavo (with plates), which, M. Temminck remarks, may be reduced to at least one half, by suppressing the numerous indications of what the author calls *subspecies.* His system is partitioned into twenty-three orders, variously subdivided, and containing 196 genera.

Some important additions have been made of late years to the Ornithology of northern countries. The birds of Sweden are described by Professor Nilson of Lund, in his *Ornithologia Suecica*, Copenhagen, 1817–21. The same author published a *Skandinavischen Fauna* in 1824; and a much more sumptuous work appeared at Lund in 1832, under the title of *Illuminerade figurer till Skandinaviens Fauna, mit text.* The first volume contains, besides quadrupeds, seventy-five figures of birds. In 1822 M. Boié gave forth his *Tagebuch gehalten auf einer Reise durch Norwegen*, in which, along with the narrative of his travels, he furnishes many valuable observations on the

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[1] See his *Observations sur la Classification Méthodique des Oiseaux*, &c. 1817; and *Manuel d'Ornithologie*, Introduction to the second edition, p. x.

[2] *Règne Animal*, second edition, tom. i. note to Preface, p. 23.

History. history and manners of the birds of Norway. The same author published a work under the title of *Ornithologische Beitrage*, in 1824. M. Faber's excellent little volume, the *Prodromus der Islandischen Ornithologie*, appeared in 1822. It contains most interesting accounts of the birds of Iceland, especially the aquatic kinds; and not less valuable is his later publication, *Uber das Leben der hochnordischen Vogel*, 1825, in which we have many acceptable observations on the geographical distribution, and the modes of life, of northern species. While on the subject of northern birds, we need scarcely recall to the reader's remembrance the various appendices to the *Voyages* of Captains Parry and Franklin,—Captain Sabine's *Memoir on the Birds of Greenland* (Linn. Trans. vol. xii.),—or the beautiful work by Dr Richardson and Mr Swainson on the birds of Northern America, which constitutes the second volume of the *Fauna Boreali-Americana*, 1831.

We have few systematic works devoted to the Ornithology of the more southern countries of the European continent. We are ourselves acquainted only by name with the *Ornitologia dell' Europa Meridionale* (dedicatio signata 1772), in fol. max., by Clement Bernini, a teacher of drawing. The birds of France in general are described by M. Vieillot in the corresponding portion of the *Faune Française*, an octavo work, still in course of publication; and those of Provence in particular, by M. Polydore Roux in his *Ornithologie Provençale*, 1825. Of a more general character, though not without its bearings on our present subject, is the *Histoire Naturelle de l'Europe Meridionale* by M. Risso of Nice, in five volumes 8vo, 1826. We have already had occasion to name the *Storia Naturale degli Uccelli*, published at Florence in 1767; and Cetti's more restricted one, *Gli Uccelli di Sardigna*, 1776. In more recent times (1811), Professor Bonelli of Turin published a *Catalogue des Oiseaux du Piémont*, containing two hundred and sixty-two species. In 1822, Giambatista Baseggio inserted in the twenty-eighth volume of the *Biblioteca Italiana* an enumeration of the birds observed by him in the neighbourhood of Bassano, amounting to a hundred and thirty-seven species. In 1823, Fortunato Luigi Naccari printed at Treviso his *Ornitologia Veneta, ossia Catalogo degli Uccelli della provincia di Venezia*, in which he notices two hundred and six species. In the same year Savi the younger published, at Pisa, his *Catalogo degli Uccelli della Provincia Pisana, e loro Toscana Sinonimia*. The species are classed in accordance with M. Temminck's system, and amount to two hundred and twenty. From 1819 to 1826, Professor Ranzani of Bologna gave forth his excellent *Elementi di Zoologia*, of which the third volume, consisting of nine parts, is devoted to the natural history of birds. It is, however, a general system, treating of exotic as well as of indigenous kinds; yet a good deal may be gleaned from it regarding the Italian species. A work of more special interest is the *Specchio comparativo delle Ornithologie di Roma e di Filadelfia*, by Carlo Bonaparte, commonly called the Prince of Musignano. In this slight but highly interesting volume (republished in the *Nuovo Giornale de' Letterati* of Pisa), the author compares the Ornithology of two distant regions of Europe and America, lying, however, under nearly the same latitude, and records his observations on their history and manners. Of the species of the Roman territory we had previously scarcely any knowledge, and the Prince makes us acquainted with not fewer than two hundred and forty-seven. By the same author we have also *Osservazioni sulla Seconda Edizione del Regno Animale del Baron Cuvier*, inserted in the tenth and eleventh fasciculi of the *Annali di Storia Naturale* of Bologna; and he has more recently commenced the *Iconografia della Fauna Italica*, Rome, 1832,—a sumptuous lithographic work, in large quarto, devoted to Italian zoology. Not more than half a dozen numbers have as yet appeared, and these contain but few examples of the feathered race. Though not relating to Italy, we may here mention our author's other works, viz. *American Ornithology, or the Natural History of Birds inhabiting the United States, not given by Wilson*, with coloured figures, three volumes quarto, Philadelphia, 1825–28 (only the land-birds have yet been published);—*Observations on the Nomenclature of Wilson's Ornithology*, Philadelphia, 1828;—and *Genera of North American Birds, with a Synopsis of the species found within the territory of the United States*, New York, 1828 (published in the *Annals of the Lyceum* of that city). The birds of Liguria are enumerated and briefly described, particularly the immature conditions of the plumage, by Girolamo Calvi in his *Catalogo d'Ornitologia di Genova*, 1828.

The latest but most important work with which we are acquainted on the birds of Italy, is the *Ornitologia Toscana* of Professor Savi, in three vols. 8vo, with additional synoptical tables, Pisa, 1827–31. Though more specially devoted to the birds of Tuscany, it also contains descriptions of all the other Italian species, and may be regarded as a most valuable addition to our knowledge of the feathered tribes of Europe. The southern position and delightful climate of the Italian Peninsula induce the wandering wings of many species elsewhere *raræ aves* to wend their way towards the olive groves and richly laden fig-trees of that favoured land,—thus connecting the Ornithology of Europe with that of Africa and other sultry regions.

We may be thought, in some of our preceding notices, to have entered too minutely into the enumeration of descriptive local works, but we have been guided in so doing by two considerations: 1*st*, That none of our English writers ever make any allusion to Italian Ornithology, except by casual reference to Carlo Bonaparte; and, 2*dly*, that Buffon has recorded as his opinion, that "le seul moyen d'avancer l'ornithologie historique, seroit de faire l'histoire particulière des oiseaux de chaque pays; d'abord de ceux d'une seule province, ensuite de ceux d'une province voisine, puis de ceux d'une autre plus eloignée; reunir après cela ces histoires particulières pour composer celle de tous les oiseaux d'une même climat; faire la même chose dans tous les pays et dans tous les différens climats; comparer ensuite ces histoires particulières, les combiner pour en tirer les faits, et former un corps entier de toutes ces parties separées."[1]

The *Natural History of British Birds*, by Donovan, in ten volumes octavo, is a work of no great merit. Its period of publication extends from 1799 to 1816.

To no one of our contemporaries is Ornithology more deeply indebted than to M. Temminck. His *Histoire Naturelle Générale des Pigeons et des Gallinacées*, three volumes octavo, appeared in 1813–15. The portion which concerns the pigeons was also published in folio, with beautiful coloured plates, by Madame Knipp. His *Manuel d'Ornithologie, ou Tableau Systématique des Oiseaux qui se trouvent en Europe*, 1815, consisted at first of a single octavo volume; but a greatly improved and extended edition in two volumes appeared in 1820. Whatever difference of opinion may prevail in regard to the author's system, naturalists are agreed that this is by far the most valuable work we yet possess on the birds of Europe. Its main excellence consists in the attention bestowed upon the sexual distinctions, and the successive changes of plumage from youth to age. The first volume contains, under the title of *Ana-*

[1] *Histoire Nat. des Oiseaux*, Plan de l'Ouvrage.

History. *lyse du Système Générale d'Ornithologie*, a classification of birds in general. Instead of a third edition of his *Manuel*, the author has recently published (in 1835) a third *part*, as a supplement to the first volume, and he is now about to give out a fourth *part*, or supplement to the second volume. These parts contain the corrections and additions rendered necessary by the lapse of many years. But M. Temminck has not confined his attention to the birds of Europe. In 1820 he commenced (in conjunction with M. Meiffren de Laugier) his *Planches Coloriées*, a work intended as a continuation and completion of the well-known *Planches Enluminées* of Buffon. It is printed in both a quarto and a folio form, now amounts to above ninety parts, and will be concluded (so far, at least, as the first great series is concerned) on the publication of the hundredth number. It will then form five volumes, composed in all of five hundred and ninety-five plates, exhibiting seven hundred and fifty-five figures of birds, the majority unknown to prior writers. Each plate is accompanied by corresponding letter-press, containing the generic characters, the description of the species figured, and in many instances by general observations on the distribution and construction of groups. The two concluding numbers are to contain a general index, as well as the tables and titles of the volumes. On the completion of this "century," we trust M. Temminck will be encouraged to proceed to another series, as we know his materials are abundant, if not inexhaustible. It would in truth be desirable that some such established work should be generally regarded as a proper medium for the publication of new or rare subjects in Ornithology, for it is the bane of natural history in general, that every year should be distinguished by the appearance of numerous abortive attempts, which each succeeding season condemns to oblivion. Thus the tax becomes both heavy and unproductive, yet we fear that national pride and personal vanity will long prevent the introduction of a better system. We do not mean to say that we possess not among ourselves individuals competent to do the subject justice, but assuredly there is much labour lost by a want of concentration.

In connection with the labours of the last-named author, we may here mention M. Werner's lithographic work, entitled *Atlas des Oiseaux d'Europe, pour servir de complément au Manuel d'Ornithologie de M. Temminck*, of which thirty-two livraisons have now appeared. M. Temminck had figured a few European novelties in his *Planches Coloriées*, but he appears to have remitted most of his rare indigenous kinds to M. Werner; and we are happy to find he is now in immediate communication, so far as the publication of his European species is concerned, with our zealous and intelligent countryman Mr Gould. This leads us to record the title of one of the most sumptuous and beautifully executed works within the whole range of ornithological illustration, viz. *The Birds of Europe*, by John Gould, F.L.S. now completed in five volumes royal folio. The plates are chiefly from lithograph drawings by Mrs Gould, but many are also by Mr Lear, one of the best ornithological draftsmen the world has yet seen. Mr Gould's other works, all of recent date, and of the same form and character as the preceding, are as follow:—*a Century of Birds, from the Himalaya Mountains;—a Monograph of the Toucans;—a Monograph of the Trogons;*—and, *a Synopsis of the Birds of Australia*. The latter is in a more portable form than the others; but it is the author's intention to illustrate the Ornithology of New Holland in the same mode as that in which he has treated the birds of Europe. History.

To M. Lesson the Ornithologist stands indebted for several publications, both of a sumptuous and useful character. The last edition of his work on humming-birds bears the following title: *Les Trochilidés, ou les colibris et les oiseaux mouches, suivi d'un index général, dans lequel sont décrites et classées méthodiquement toutes les races et espèces du genre Trochilus*, Paris, 1832, with seventy coloured plates. Conjointly with M. Garnot, he has published some figures of birds in the Zoological Atlas to Duperrey's *Voyage autour du Monde*, as well as in his own *Centurie de Zoologie*. His other works specially devoted to our present subject are,—*Manuel d'Ornithologie*, two volumes 18mo, 1829; *Traité d'Ornithologie*, two volumes 8vo (with 119 plates), 1831; and *Histoire Naturelle des Oiseaux de Paradis, des Séricules, et des Epimaques*, one volume 8vo (with 41 coloured plates), 1835.

Mr Swainson's beautiful *Zoological Illustrations* (First Series 3 vols. 8vo, 1820–23, Second Series 3 vols. 8vo, 1832–3) contain representations of many rare and remarkable birds, and yield to none with which we are acquainted, either in elegance or accuracy. By the same author (conjointly with Dr Richardson) we have, as already noted, the *Fauna Boreali-Americana*, Part Second; and (without other aid than his own delightful pencil) several fasciculi of the *Birds of Brazil*. More recently Mr Swainson has entered into a minute as well as extended exposition of the *Natural History and Classification of Birds*, in two volumes (1836–7), which form the ornithological portion of Dr Lardner's Cyclopædia. These will amply repay the most attentive study.

The birds of South America, which, like all the productions of that splendid country, are extremely gorgeous, have been here and there illustrated in various works, and are partially so by Mr Swainson in one of those just named. In Azara's *Voyages dans l'Amérique Méridionale* (1809, 3d and 4th volumes) there are descriptions of many hundred species from Paraguay and La Plata. The ornithological portion of the French edition was translated, with notes, by Sonnini.[1] A great mass of Brazilian species is described and figured in Spix's *Avium Species Novæ*, &c. 2 vols. 4to, 1824–26; while the habits of several of the more curious birds of Demerara are recorded in Mr Waterton's eccentric and well-known *Wanderings*.

The Ornithology of North America has been illustrated in an extremely full and satisfactory manner. Indeed, of the feathered tribes of no country out of Europe, equal in extent, do we possess so ample and accurate a knowledge as we do of those of the United States. We have already mentioned the immortal work of Alexander Wilson, and its excellent continuation by Charles Lucien Bonaparte; but at present we have to record the title of a much more magnificent publication than either, we mean *The Birds of America, engraved from Drawings made in*

[1] The truly important works of Don Felix Azara seem better known to European readers by the French translations than the original Spanish publications. He devoted all his leisure hours, whilst in South America, to the pursuits of natural history, from the year 1782 to 1801. He then transmitted the manuscript of his *Apuntamientos para la Historia Natural de los Quadrupedos del Paraguay* to his brother, Don Josef Nicolas, who handed it over to a French professor, M. Moreau de Saint Méry, by whom it was translated, and published under the now well-known title of *Essai sur l'Histoire Naturelle des Quadrupèdes du Paraguay*, 2 vols. 8vo, Paris, 1801. The original, however, appeared at Madrid in the following year, with corrections and additions by the author. In 1802 he likewise published his ornithological work under the title of *Apuntamientos para la Historia Natural de los Pajaros del Paraguay y Buenos Ayres*; and this portion of his labours forms the two concluding volumes of the French translation, entitled *Voyages dans l'Amérique Méridionale de* 1781 *jusqu'en* 1801, 4 vols. 8vo, Paris, 1809. We are glad to understand that Mr W. Perceval Hunter proposes to publish an English translation of both works, from the original Spanish, with notes.

History. *the United States*, by John James Audubon, F. R. S., &c. 3 vols. folio, London, 1831–37; an undertaking which far exceeds in size and splendour all its predecessors in this, or indeed in any other department of Zoology. The dimensions of the work, as we have elsewhere noticed, are such as to enable the author not only to represent the largest birds of the United States, of the size and in the attitudes of living nature, but to figure a great proportion of them in family groups, so admirably conceived and skilfully executed, as really to form historical pictures of the highest interest to the general observer, and of the greatest utility to the student of Ornithology. The completion of each volume of plates is immediately followed by a large octavo volume of descriptive and general history of all the species therein contained. Mr Audubon far excels Wilson as an ornithological draftsman, and often equals him in his lively, eloquent, and interesting details of the life and manners of the feathered tribes. His descriptive volumes are entitled *Ornithological Biography, or an Account of the Habits of the Birds of the United States.* They at present amount to three in number; and a fourth and final one, to accompany the concluding fasciculus of his splendid plates, is now on the eve of publication.

An extremely useful and well-concocted work, of less ambitious form than the preceding, is the *Manual of the Ornithology of the United States and of Canada*, by Thomas Nuttall, F. L. S., in two compact octavo volumes, Cambridge and Boston, 1832–34. The author has recently returned from a scientific tour through the great western territories, including an extended range of the Rocky Mountains; and, we doubt not, the public will benefit by whatever account he gives of his researches.

Although we have hitherto confined our bibliographical notices chiefly to the works of foreign writers, we have done so not in consequence altogether of our own poverty, but rather for the more ample information of the English reader, who may be supposed to require less assistance in regard to British authors. We have scarcely even named the *British Birds* of the unequalled Bewick. We name it, and nothing more, believing that every one who delights to see nature in art, is familiarly acquainted with a work which may be keenly relished without any arduous study, but which those who study most will best appreciate and enjoy. Although the descriptive portion is written with accuracy and intelligence, we doubt not it would be advantageous to the author's family, and prove a labour of love to one or more of the many skilful Ornithologists of the present day, that the plates should be re-arranged in conformity with modern views, the supplement incorporated, the synonyms increased, and such rational alterations or additions effected, as would render it the manual of British Ornithology, if not for all time coming, yet for many future years. If accompanied by portions of the author's autobiography, so much the better. We regret that the latter, so racy and original, should have not yet seen the light. The most recent and complete edition of Bewick's Birds is that of 1832. A very beautiful preface is prefixed to the one published in 1826.

The most original *descriptive* works on the birds of Britain are Montagu's *Ornithological Dictionary*, 2 vols. 8vo, 1802, and *Supplement* to the same, 1 vol. 8vo, 1813. These were not only excellent works on *British* birds simply as such, but valuable additions to the actual history of European species,—the chief merit of many of our other publications consisting in their applying the knowledge acquired by foreign writers to our indigenous kinds; whereas Montagu rather gave than borrowed, his observations being almost entirely original. His volumes are now extremely rare in their first form; but a new edition, combining both works in one, was brought out in 1831, with notes, by Mr Rennie.

Dr Fleming, in his *History of British Animals*, one vol. octavo, 1828, enumerates and describes the birds of Britain. Of this work, which has been very useful to some who say rather too little about it, we should desire to see a new edition, remodelled in accordance with the alterations and additions rendered necessary by the lapse of years. It is a publication of great merit. History.

The letter-press to Mr Selby's folio *Illustrations of British Ornithology* (we mean the second edition, in two vols. 8vo, 1833) forms the best completed work we yet possess in accordance with the modern method of arrangement. Jointly with Sir William Jardine, Mr Selby has also brought out many fasciculi of *Illustrations of Ornithology* (small folio), in which are figured various interesting and curious forms of foreign species; and his well-instructed coadjutor is editor (and of several volumes author) of the *Naturalist's Library*, in which a due portion is successfully devoted to the history and representation of the feathered tribes. Both publications continue at the present time (1838).

One of the most valuable and carefully constructed works with which we are acquainted is the *Systema Avium* of Dr Wagler, pars prima, Stuttgard, 1827. It consists of a series of monographs, not in systematic order, but including several extensive and difficult genera, such as *Picus*, *Columba*, &c. The author unfortunately died not long ago, in consequence of a gun-shot wound accidentally inflicted by himself while sporting, and the non-completion of his work may be regarded as a great loss to Ornithologists. Various additional though detached portions of it, however, may be found in the *Isis*, a German periodical published at Frankfort. Wagler is also the author of the most recent descriptive summary of the parrot tribe, under the title of *Monographia Psittacorum*, one vol. 4to, Munchen, 1835. Our best previous treatise on that gorgeous family was published by the lamented Kuhl, in the *Nova Acta* of Bonn, vol. x. Of illustrated works on the subject, we have already mentioned that of Vaillant; and the English reader need scarcely be reminded of the extreme beauty of Mr Lear's more recent *Illustrations of the Psittacidæ*, in one vol. royal folio.

A considerable flock of ornithological authors has recently appeared above the horizon, to enlighten, however, rather than obscure our vision. We shall name a few.

Outlines of the Smaller British Birds, by R. A. Slaney, Esq. 12mo, 1833.

Familiar History of Birds, by the Rev. Edward Stanley, 2 vols. 12mo, 1835.

Manual of British Vertebrate Animals, by the Rev. Leonard Jenyns, 1 vol. 8vo, 1835.

Feathered Tribes of the British Islands, by Robert Mudie, 2 vols. 8vo, 1836.

History of the rarer British Birds, intended as a supplement to Bewick, by T. C. Eyton, Esq. 1836.

Of these, and other contemporary writers, the reader will find more ample notice in Mr Neville Wood's *Ornithologist's Text-Book* of 1836.

The following works relate particularly to the more musical of the feathered tribes: *Harmonia Ruralis, or Natural History of British Song Birds*, by James Bolton, folio, 1794;—*British Warblers*, by Robert Sweet, F. L. S. 8vo, 1823–32;—*Treatise on British Song Birds*, by Patrick Syme, Esq. 8vo, 1823;—*British Songsters*, by Neville Wood, Esq. 8vo, 1837;—*Cage Birds, their Natural History, Management*, &c. (translated from the German), by J. M. Bechstein, 12mo, 1837.

Mr Yarrell has commenced his much-desired *History of British Birds*, illustrated by a wood-cut of each species, and numerous vignettes. The illustrations are for the most part remarkably accurate as ornithological representations, and of extreme beauty in a pictorial point of view.

Structure. From the author's excellent reputation as a naturalist, as well as from the specimens hitherto published, we should augur that this work, on its completion, will form as valuable a manual of British Ornithology as can be well desired.

Last in our list, though the reverse of lowest in our estimation, stand Mr Macgillivray's characteristic volumes, the *Rapacious Birds of Great Britain* (1836), and the *History of British Birds, Indigenous and Migratory* (vol. 1st, 1837). In regard to these two works, readers may probably differ in their appreciation of some insulated passages, critical or otherwise, not essential to the exposition of the subject in hand; but we think all must agree that they are written in a clear, vigorous, and original manner, and devoid of that vapid spirit of compilation which pervades the labours of so many of the ingenious author's predecessors and contemporaries.

We shall not here enter into any detailed exposition of the internal structure of birds. Our space would not admit of our doing so in a manner likely either to satisfy ourselves or to instruct our readers. The subject is of too great importance to be superficially treated, and a deeper scientific examination is not to be looked for here. We regret to say, there is much reason to accuse the naturalist of confining his attention to the external characters of living beings, which, though important portions of the animal economy, are nevertheless only portions, though too often looked upon as all in all. It is no reason for neglecting the internal structure, that a knowledge of such structure is not required to comprehend the modern systems. This, we must admit, is true; but the systems are thereby so much the more defective. An assured anatomical basis will never cause confusion or contrariety in any *good* arrangement formed on the groundwork of external characters; for the best of these are sure to conform themselves with all the important modifications of internal structure, while the sooner a bad arrangement is undermined the better. At the same time, that Zootomist would know little of the practical importance of external forms who should not endeavour to connect these with his demonstration of more recondite characters. In truth, however desirable it may be to know the whole of the animal structure, whether external or internal, we must in relation to museum specimens and to zoological collections in general, necessarily have recourse to superficial, or at least external characters, because none other are visible, or indeed exist, in the subjects of natural history as usually preserved; and we should debar a vast multitude from a most delightful study of graceful forms and gorgeous plumage, if we could learn nothing important of beast or bird without prying into all the hidden wonders of its interior. Whatever progress comparative anatomy may in future make, we trust the Zootomist will ever bear in mind that the establishment of good external characters is a matter of the highest and most indispensable importance to the present state and future progress of natural history, of which the practical pursuit will ever mainly depend upon the class of characters in question. As we cannot here enter into the anatomical department of our subject, we shall give, in the subjoined note, the names of a few works likely to interest and instruct the reader.[1] A few paragraphs will suffice for all we have ourselves to say, before entering upon our systematic portion.

The bill, composed of the upper and under mandible, varies almost infinitely in its form in the different genera, in the determination and construction of which it affords characters of the highest importance. As its modifications will be specially alluded to in our notices of the minor groups, and are moreover accurately represented in the plates which accompany the present treatise, we need not here fatigue the reader by an unnecessary enumeration. A portion at the base of the upper mandible, usually containing the nostrils, and sometimes covered with hairs or feathers, sometimes partially or entirely bare, is called the *cere*. It is very obvious in most birds of prey, but imperceptible in many other species. When we expand the mandibles, we of course perceive the opening to the alimentary canal or digestive organs, which usually consist of the following portions. Structure.

The *pharynx* follows immediately after the cavity of the mouth. It leads into the *œsophagus* or gullet, which in many species swells into what is called the *crop*, by some regarded as the first stomach. This is followed by a second enlargement, produced, however, rather by a thickening of the coats than by any increase of capacity within, named the *proventriculus*. It contains numerous glandular sacs interposed between its muscular and mucous coats, which secrete a gastric juice to aid the process of digestion. This proventriculus leads to the *gizzard* or true stomach, by some regarded as the third stomachic expansion. Here the function of digestion is completed. The entrance from the stomach to the small intestine is named the *pylorus*, of which the structure is frequently valvular. The first fold of the small intestine is named the *duodenum*, and after receiving the pancreatic and biliary ducts, it forms various convolutions, and terminates in the rectum or large intestine. The *cæca* are usually placed at the commencement of the latter; its termination is named the *cloaca*.

These parts, it will be borne in mind, are variously modified in the different tribes. In some the expansion called the crop is wanting, or not to be distinguished from the other upper portions of the œsophagus; and the powerful muscles which constitute the peculiar strength of the gizzard in granivorous birds are very feeble in the carnivorous and fish-devouring kinds. In some the intestine is long and narrow, in others short and wide, while the cæca exhibit a corresponding range, being in certain kinds extremely long, in others merely rudimentary.

Birds are remarkable for the energy of their respiratory functions. Although their lungs are rather small, they are perforated in such a way as to communicate with membranous cells distributed through various parts of the body, and even communicating with the interior of the bones, so that the atmospheric air not only comes in contact with the pulmonary vessels, but with a great proportion of the circulating system. Thus birds have been said to respire by the branches of the aorta, as well as by those of the pulmonary artery. It is thus that the most rapid exercise of the faculty of flight impairs not their power of breathing; and the best-trained hunter that ever bounded rejoicingly over the fences of Leicestershire is far sooner blown than a field sparrow.

The *trachea* or wind-pipe is composed of bony rings. The *upper larynx* is of comparatively simple structure, and of less importance than among the mammiferous class; but farther down, and close upon the bifurcation of the trachea, is the *lower larynx*, the true organ of the voice in birds. The vast bulk of air contained in the interior cells no doubt contributes to the strength of their vocal powers, while the muscles of the inferior portion of the larynx, and

[1] Cuvier's *Leçons d'Anatomie Comparée*; Carus's *Introduction to Comparative Anatomy*, translated from the German by Mr Gore (there is a better and more recent French edition of this work); Meckel's *Traité Général d'Anatomie Comparée*; Grant's *Outlines of Comparative Anatomy*; Mr Owen's article AVES, in Todd's *Cyclopædia of Anatomy and Physiology*; and the *Introduction* to Macgillivray's *History of British Birds*, vol. i.

Structure. the length, diversified form, and varied movements of that organ, bestow upon it a great facility of modulation.

The anterior limbs of birds, corresponding to the fore legs of quadrupeds, have been converted into wings for the purposes of that aërial locomotion commonly called flight. It is true that some birds cannot fly, that is, leave not the surface of the earth; but these are exceptions to the general rule, and even among such exceptions the great majority use their wings as a propelling power, whether coursing amid dry and barren deserts, or submerged beneath the waves. The bony portions of the wings consist of the *humerus*, the *cubitus*, the *carpal* and *metacarpal* bones, and *fingers*. We shall briefly describe these parts in so far as they are connected with the imposition of the plumage, and consequently with the external characters of the feathered race. The reader, if he so inclines, may here consult Plate CCCLXXXVII. figs. 3 and 4. The *humerus* or armbone (*c*) is joined to the body by means of a part of its own upper surface, which articulates with a corresponding cavity between the coracoid bone (*b*) and the scapula or shoulder-blade (*a*). It is directed backwards in repose, and in a position more or less parallel with the spine. The other extremity of the humerus articulates with the *cubitus* or fore-arm, which is composed of the bones called the *ulna* (*d*) and *radius* (*e*), and is so jointed as to fold when at rest in a direction parallel to that of the arm. The *carpus* consists of two small bones (*ff*) placed between the outer extremity of the cubitus and the *metacarpus*. The latter (*g*) usually consists of two bones united at both ends. From the anterior edge of the portion next the carpus, there projects a small bone, considered as analogous to the first digit or thumb, *pollex* (*h*); to the extremity of the outer portion of the metacarpus are usually attached two other digital bones (*ij*); and to the extremity of its inner portion is frequently appended a smaller bone of corresponding nature. These are the *fingers* of birds.

Now, the connection of the *plumage* with the preceding parts is as follows. Here consult Plate CCCLXXXVII. figs. 1, 2, 5. The small elongated tuft of stiffish feathers which clothe the upper exterior margin of a bird's wing, increasing in size downwards, pointing towards the base of the outer primaries, and commonly called the *alula*, or spurious wing (see S. W. in figs. 1, 2, and 5), springs from the portion we have called the thumb. The *primaries* or greater quill-feathers of the wings, that is, the *ten* outermost feathers, and which constitute the more or less pointed terminal portion (see figs. 1, 1 to 10, and figs. 2 and 5, at P. P.), spring from the digital and metacarpal bones. The *secondaries*, or lesser quill-feathers (figs. 1, 1 to 6, and figs. 2 and 5, at S. S.), which, when the wing is closed, usually cover a portion of the primaries, take their origin from the cubitus or fore-arm; while a third series, inconspicuous in most birds, though very obvious in others, and named the *tertials* or tertiary feathers (fig. 2, T. T.), are derived from the humerus or arm bone. Above these, and lying over that portion of the wing which joins the body (or, as it were, between the wing and back), are the *scapulars* (fig. 2, Sc.), usually of an elongated form, and often distinguished from the surrounding plumage by a difference of tint or marking. Lastly, various ranges of feathers which clothe the upper portion of the wings from the carpal joint backwards, covering the base of the primary and secondary quills, and spreading across from the spurious wing to the scapulars, are named the *wing coverts*, and are distinguished, according to their position, as the smaller coverts (figs. 1 and 2, at Sm. C.), which clothe the upper portion of the wing; the secondary coverts (figs 1 and 2, at S. C.), which protect the base of the secondaries; and the primary coverts, Structure. (figs. 1 and 2, at P. C.), which perform that office to the primaries. The feathers which clothe the under surface of the wings are named the *under coverts* of those parts; and the terms *upper* and *under tail-coverts* signify the feathers which cover the base of the tail, above or below. But we need scarcely occupy our pages with the numerous particulars which might be brought forward, and which occupy so prominent a space in many ornithological volumes. The terms in most cases explain themselves. When we speak of the crest of a bird, we of course mean to indicate the feathers on its head; and the upper, central, or lower portions of the back, can be respectively nothing more nor less than one or other of these portions. When we mention the point of the bill, we literally mean the point, and there is no word in the English nor in any other language which can express it more clearly. Neither do we think it necessary, in an English work, to give a corresponding Latin phrase for every term we use, more especially as many of these terms cannot be correctly Latinized, and in fact have never occurred at all in any books in that language. Their confinement, therefore, in a circumflexual prison, amid the unembarrassed freedom of the English tongue, is a sad and cruel mockery "of things attempted yet in prose or rhyme;" and we believe is but seldom practised by those who got through Ruddiman respectably in early life. We therefore deem it worse than useless to present an endless catalogue of *terms in Ornithology*, followed by explanations more obscure and ambiguous than the technicalities themselves; but shall rather endeavour either altogether to avoid unknown tongues, or, by the context, to render our meaning obvious to each capacity.[1]

Those minute discriminations, so often insisted on, are in truth but seldom necessary in the description of a bird's external aspect, especially of its feathered portions, because large spaces of the plumage have frequently an identical character both in texture and colour. Thus, if the entire head is either black, white, brown, or any other single colour, it would be a waste of words to describe it in any other way than simply as being of that colour; that is, it would be unnecessary to say that the frontal, vertical, occipital, auricular, and ocular feathers of the head were coloured after such a fashion; but if one colour prevails over another, and yet is traversed, or in any way varied by other colours, the precise region, whether frontal or occipital, in which the variation happens should be stated. We would almost say, that our nomenclature of the parts themselves depends to some extent on the distribution of the colours. Thus, of birds with a black abdomen and a scarlet breast, we can easily conceive, that even of the same species two individuals may so considerably differ in the proportional extent of the supposed colours, that the black in one instance shall encroach upon what corresponds to the scarlet of the other, or *vice versa*; but still the phrases "abdomen black, breast scarlet," would suffice for both, though not proportionally the same in each. The fact is, that many of the special regions of a bird are by no means precisely marked, or at least are seldom seen to be so, unless we strip it of its plumage,—an untoward act, however, for one who desires to stuff or otherwise preserve its skin; and therefore some latitude must be allowed in our expression of the external parts.

The next portion to be briefly described is the leg or hinder limb. This is divisible into the *femur*, *tibia*, *tarsus*, and *toes*. See Plate CCCLXXXVII. fig. 3.

The *femur*, or thigh-bone (*k*), is cylindrical, somewhat

[1] A very ample and interesting account of the diversified form of bills, feet, and feathers, will be found in Mr Swainson's *Natural History and Classification of Birds*, vol. i., illustrated by numerous wood-cuts from the elegant pencil of the author.

Structure. curved, usually very short, and always so concealed within the body as not to be apparent as an external portion of the limb. The next division is the leg or *tibia* (*m*), frequently but erroneously called the thigh, probably from its being the uppermost apparent portion. It is usually covered with feathers, though sometimes bare on its lower portion. Then follows the *tarsus* (*n*), that long, slender, exposed portion, so conspicuous in almost all the species, varying considerably among accipitrine birds, rather short in web-footed water-fowl, and greatly lengthened in the majority of shore-birds or waders. Its upper knobby portion, where it articulates with the tibia, is the true heel, although generally in colloquial, and not seldom in descriptive language, termed the knee. The prominences of its lower extremity articulate with the *toes*. The latter parts usually amount to four; the hind toe, however, is wanting in many species, and the ostrich is generally supposed to have only two toes, although Dr Riley has demonstrated the existence in that bird also of a rudimentary inner toe. The hind toe is by some regarded as the first, the inner as the second, the middle as the third, and the outer as the fourth toe; and in this order there is a progressive increase in the number of the joints of which each is composed,—the first having two, the second three, the third four, and the fourth five bones. The surface of the tarsus, toes, and sometimes of the base of the tibia when that part is exposed, is covered either with plated or reticulated scales, of various forms in different species; and the tarsus is moreover often armed with one or more spurs,—which, however, belong to the cutaneous rather than the osseous system. A general notion of the latter, as it exists in the class of birds, may be acquired by an inspection of the skeleton of the golden eagle just referred to (Plate CCCLXXXVII. fig. 3). We shall here add nothing more upon the subject.

The position, and therefore to a certain extent the nature, of many modern genera, of which we are unable from want of space to give the characters, will be seen in the tabular views with which we terminate the present treatise. A considerable discordance still prevails in regard to the nature and amount of the generic groups in Ornithology,—some writers advocating a numerous subdivision, and consequent restriction, of characters; while others adhere, perhaps too tenaciously, to old associations, which naturally tend to the augmentation of species, in other words, to the extension rather than the increase of genera. The former plan is rendered necessary to a great extent by the vast additions which have been made to our knowledge of groups and of typical species within the present century, and might be deemed advisable among the larger genera even as a mere matter of convenience;—its abuse in the hands of unskilful or inexperienced persons being of course no legitimate argument against it. There is, however, a great deal that is arbitrary and unsettled in whatever principle may be supposed to guide the modern naturalist in the formation of his generic groups. The simplicity and ease of application which characterised the former artificial systems have been lost in their attempted demolition, while the reconstructions now arising (in spite of the abundant though not always acknowledged appropriation of some useful old materials) are not yet so complete and commodious as to afford the same accommodation to the benighted student. Order will no doubt some day spring from chaos, and even already, amid the darkness of the upheaving waters, are many sunny spots of terra firma towards which we fondly steer, "well pleased that now our sea should find a shore." Naturalists, however, need by no means quarrel with each other, as if there was a certain good to gain, or some great physical truth to be established. "All the great business of genera and species," says Locke, "amounts to no more but this, that men make abstract ideas, and, setting them in their minds with names annexed to them, do thereby enable themselves to consider things, and discourse of them, as it were in bundles, for the easier and readier improvement and communication of their knowledge, which would advance but slowly were their words and thoughts confined only to particulars." "The reason," he says again, "why I take so particular notice of this is, that we may not be mistaken about genera and species, and their essences, as if they were things regularly and constantly made by nature, and had a real existence in things,—when they appear upon a more wary survey to be nothing else but an artifice of the understanding, for the easier signifying such collections of ideas, as it should often have occasion to communicate by one general term, under which divers particulars, as far forth as they agreed to that abstract idea, might be comprehended." Genera.

The following observations by Mr Vigors may be introduced with propriety in this place, as according closely with our own views on the subject of generic divisions. "But though nature nowhere exhibits an absolute division between her various groups, she yet displays sufficiently distinctive characters to enable us to arrange them into conterminous assemblages, and to retain each assemblage, at least in idea, separate from the rest. It is not, however, at the point of junction between it and its adjoining groups that I look for the distinctive character. There, as M. Temminck justly observes, it is not to be found. It is at that central point which is most remote from the ideal point of junction on each side, and where the characteristic peculiarities of the groups, gradually unfolding themselves, appear in their full development; it is at that spot, in short, where the typical character is most conspicuous, that I fix my exclusive attention. Upon these typical eminences I plant those banners of distinction, round which corresponding species may congregate as they more or less approach the types of each. In my pursuit of nature, I am accustomed to look upon the great series in which her productions insensibly pass into each other, with similar feelings to those with which I contemplate some of those beautiful pieces of natural scenery, where the grounds swell out in a diversified interchange of valley and elevation. Here, although I can detect no breach in that undulating outline over which the eye delights to glide without interruption, I can still give a separate existence in idea to every elevation before me, and assign it a separate name. It is upon the points of eminence in each that I fix my attention, and it is these points I compare together, regardless, in my divisions, of the lower grounds which imperceptibly meet at the base. Thus also it is that I fix upon the typical eminences that rise most conspicuously above that continued outline in which nature disposes her living groups. These afford me sufficient prominency of character for my ideal divisions; for ideal they must be, where nature shows none. And thus it is that I can conceive my groups to be at once separate and united; separate at their typical elevations, but united at their basal extremes.

"It is difficult to convey, in terms sufficiently explicit, an accurate definition of abstract notions like the present. We may see the subject clearly ourselves, but not be able to communicate it by words sufficiently intelligible, unless to those who may happen to view it in the same light as ourselves. I shall therefore take a familiar illustration, which comes home to the feelings of every man, and where it will be immediately apparent that strongly marked divisional groups may be kept apart from each other in our conceptions, although we can recognise no absolute boundary lines by which we can say they are separated.

"Let us take, for instance, that period of time which in-

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volves the annual revolution of the earth round the sun, and let us divide it into the usual departments which we call seasons. Every man can picture to his own mind the decided characters by which these divisions of the year are parted from each other; he can mark out by definite distinctions those striking periods where the year bursts forth into bud, where it opens into flower, where it ripens into fruit, and where it lapses into decay. He can ascertain the nature of the impressions which each season forces upon his own feelings, he can communicate such sensations to others, and he can embody those natural periods, of whose separate existence he feels conscious, into separate and well-characterised divisions, to which he can refer, without fear of being misunderstood, under the distinct appellations of spring or summer, of autumn or of winter. But can he at the same time point out the actual limits of these natural departments of the year? Can he fix, for instance, in that intervening interchange of season, where the rigour of winter silently and imperceptibly relaxes into the mildness of spring,—can he fix, I say, upon the exact period when the former terminates, and the latter begins? Can he assert at one moment that he is within the precincts of one season, and that, even while he speaks, he has passed into the confines of the other. He may, it is true, assign artificial limits to each department, and may calculate with mathematical precision the months, the days, the hours, of which it consists. He may even assign reasons for his arbitrary divisions, and prove their probable approximation to the regular interchange of nature. And this is precisely as far as the Zoologist can go. But this is all that is in his power. He never can feel or assert that the character of one season is lost at one particular moment, and gives place to the character of that which succeeds. Here, then, we have four decided divisions, perfectly distinct in themselves, yet to which we are unable to affix the limits. So it is with the groups of Zoology. They exhibit separate divisions, distinguished by separate characters, but running into each other without any assignable limits; and any man may draw his imaginary line across that 'border country,' that 'land debateable,' which stretches between the conterminous regions, according as it suits his fancy or his peculiar views, or as it may accord with the greater or less preponderance of those minor landmarks which serve as an inferior mode of demarcation in the absence of all natural boundaries."[1]

We shall now proceed with our proposed exposition of the various orders.

Order I.—RAPTORES, OR BIRDS OF PREY.[2]

Raptorial birds, under which term we include the tribes usually known by the general names of vultures, eagles, hawks, buzzards, kites, and owls, are distinguished by a strong, sharp-edged, acutely-pointed bill, more or less curved, but always hooked at the extremity of the upper mandible, which is covered at the base by the membrane called the cere. The nostrils are usually open. The legs, with few exceptions, are plumed as far as the top of the tarsus; the latter part itself is usually bare, but is entirely covered with feathers in most of the nocturnal kinds, and partially so in several of the diurnal. The toes are always four in number, very free in their movements, the outer sometimes versatile; and the whole, with rare exceptions, are furnished with strong, sharp, curved, prehensile claws.

All raptorial birds feed on animal substances,—the majority on living prey. Representing in their own class the ferine species among quadrupeds, they subdue their weaker brethren by force more frequently than guile; and if not more tyrannical than tigers, they at least exercise a more extended sway, for the fields, the woods, and waters, the barren mountains, and resounding shore, are all alike subjected to their fierce control. Their power of flight is remarkable for its surpassing strength and long endurance. They occur in some form or other under every clime, and their external aspect varies greatly, both in size and shape, from the ponderous eagle and condor of long extended wing, to the finch-falcon of Bengal, which is scarcely larger than a sparrow. But, generally speaking, raptorial birds are of considerable bulk, as might be anticipated from the necessity under which they lie of subduing an active and not always unresisting prey. Their forms, however, are often graceful, their actions energetic, their eyes bold and bright, and their plumage beautifully varied;—but they are more remarkable for chaste and subdued colouring, for sober shades of intermingled black and brown, than for those brilliant or gorgeous hues which characterise so many of the feathered tribes.

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Their dispositions naturally fierce or unaccommodating, if not contentious, their ravening appetites, and dangerous weapons, induce them but seldom to associate with each other. We shall not here describe them, after the manner of many authors, as gloomy and mistrustful,—for what cause has an eagle, rejoicing in his strength, and winging his way from distant isles o'er waters glittering with redundant life, or hovering on the side of some majestic mountain, of which the purple heath is one wide storehouse of the best of game,—what cause has he for gloom? Or why should he mistrust, whose sail-broad vans might almost carry him across the vast Atlantic, or assuredly in a few brief hours transport him from his bold but barren eyrie, to richer pastures, reverberating with the varied voices of defenceless flocks? We believe there is nothing mournful or disconsolate in beings which pursue the unfettered exercise of natural instinct. Such fearful attributes are but reflections from the melancholy mind of man (whose morbid *reason* often casts a gloom across the brightest sun), but cloud not in reality the face of nature. Birds of prey, however, are not gregarious,—although, "where the carcass is, there will the eagles be gathered together." For eagles we presume to read vultures, the scavengers of the raptorial order, which in sultry regions are highly useful in clearing all decaying offal from the earth. With these exceptions, the others may be said to dwell in single pairs,—at times in solitude. They build their rude but sufficing nests amid precipitous rocks, on ancient ruins, and occasionally among forest trees, while a few take up their station on the ground. They seldom lay more than four eggs, and many only rear a pair of young. These are at first extremely helpless, and covered for a time with down. The females, in the generality of species, are considerably larger than the males. The plumage of the sexes often differs greatly, and in such cases the offspring for one or more seasons resembles the mother.

The voice in the raptorial order is almost always harsh and unmusical, sometimes more plaintive in the hooting kinds, complaining by night from ivy-mantled tower or ancient tree; and only one species, a hawk from Africa, has been ever said to sing. The uses to the human race of birds of prey are not remarkable. The scavengers above alluded to are beneficial in their way, but the same can scarcely be alleged of such as carry off our lambs or poultry; and we are not aware that either their flesh or feathers are of much avail. More might have been said of certain members of the order, had not the practice of

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[1] *Zoological Journal*, No. ii. p. 196.

[2] Accipitres, Linn.; Rapaces, Temm.

Raptores. falconry, with other chivalrous uses, been about to pass away.

SECT. I.—DIURNAL BIRDS OF PREY.

Cere usually naked, or partly covered by setaceous feathers. Nostrils open. Eyes of medium size, lateral. Head rather small, and elongated; face not surrounded by a completed disk of projecting feathers, as in owls. Sternum strong and solid. Stomach membranous. Intestines not greatly extended. Cæca short. Toes naked.

Of this section Linnæus and the other naturalists formed only two genera, *Vultur* and *Falco*, which some regard as forming two large families, subdivided into numerous minor groups. There is, upon the whole, a well-marked character, or at least a strong physiognomical distinction, between the *Vulturidæ* and *Falconidæ;* but this is more easily seen than expressed, or, when expressed, is often erroneously so. Thus a strong alleged distinction is the nearly naked head of the former; but the lammer-geyer (*G. barbatus*) has that part as densely plumed as any eagle. However, the nails are generally blunt, and the feet comparatively feeble.

FAMILY I.—VULTURIDÆ.[1]

The birds of this family are of large size and gluttonous habits. They prefer animal substances in a state of decomposition to living prey, and are frequently gregarious. The bill is never notched, and the feet and claws are more feeble and less curved than among the Falconidæ. Though indolent, especially after meal time, they are distinguished by great powers of flight. Their bodies in repose assume a more or less horizontal position. Their flesh is disgusting as an article of food, but their down has been occasionally made use of for domestic purposes.

Genus Vultur, Cuv. Bill large and strong, compressed, straight at the base, convex and rounded at the point. Nostrils naked, rounded, obliquely pierced. Head and neck bare of ordinary feathers, but covered by a short down. A collar of long soft feathers at the base of the neck.

The true vultures, as now restricted, belong to the ancient world. Their flight, though slow, is powerful and long sustained. They frequently rise, by repeated gyrations, to a great height in the air, and descend in a similar manner. They assemble in troops, and feed for the most part on carcasses; yet the Dalmatian shepherds are said to dread their inroads among their sheep and lambs. They build among inaccessible rocks, and feed their young by emptying the unsavoury contents of their own crops. It does not appear that they can transfix or carry off their prey by means of their talons, as do hawks and eagles.

We have two species in Europe, the cinereous vulture (*V. cinereus*, Linn. Plate CCCLXXXVIII. fig. 1), called *arrian* on the Pyrenees, and the *griffon* or fulvous vulture (*V. fulvus*, Linn.). Both birds occur in Spain and the Tyrol, but are scarcely ever seen in Switzerland, and are rare in Germany. The nidification of the cinereous vulture is still unknown. It probably never breeds in Europe, but rather in the mountainous countries of Asia, where it is known to occur abundantly. The fulvous vulture is more courageous than the preceding, and more inclined to seize on living prey. It is common in the neighbourhood of Gibraltar, abounds in Dalmatia during winter, and has been observed to breed in Sardinia on lofty trees. It lays two eggs, of a greenish white, with a rugose surface. It is widely spread over the continent of Africa. Several other species are found in the warmer regions of the old world. Raptores.

Genus Sarcoramphus, Dumeril.[2] Bill thick, straight from the base, but strongly curved at the extremity, the margin of the upper mandible having a somewhat sinuous or S-like outline. Nostrils longitudinal and oblong. Head and neck bare, wattled, surmounted by a fleshy crest.

This genus is confined to America, and consists of three species, the famous condor of the Andes (*S. condor*), the king-vulture (*S. papa*), and the Californian vulture (*S. californianus*). The condor inhabits the loftiest of the Andes, and in its aërial flights is supposed to attain to a station far above that of every other living creature. According to Humboldt, it soars to an elevation nearly six times greater than that at which clouds are usually suspended in the sky. At the vast height of almost six perpendicular miles, the condor is seen majestically sailing through the ethereal space, watchfully surveying the airy depth in quest of his accustomed prey. When impelled by hunger, he descends to the nearest plains which border on the Cordilleras; but his sojourn there is brief, as he seems instinctively to prefer the desolate and lofty mountains. The barometer amid such aërial haunts attains only to the height of sixteen inches. These rocky eyries (of which the plain is elevated about 15,000 feet above the level of the sea) are known vernacularly by the name of *condor nests*. There, perched in dreary solitude, on the crests of scattered peaks, at the very verge of the region of perpetual snow, these dark gigantic birds are seen silently reposing like melancholy spectres. Hardly an instance is known of their assaulting even an infant, though many credulous travellers have given accounts of their killing young persons of ten or twelve years of age.[3]

The history of the condor, like that of its Patagonian neighbours of the human race, has in fact been much obscured by exaggeration. An inspection of its feet and claws suffices to show that it is not gifted with great prehensile power, and could scarcely carry off the most ill-conditioned child, though not seldom accused of such evil practices. Condamine informs us that he has often seen condors hovering over flocks of sheep, some of which they "would have carried away, had they not been scared by the shepherds;" and this vague supposition is stated as a *fact* in their natural history! It is a bird of powerful wing, but of vulturine habits, feeding much on dead animal matter, but not unfrequently joining together in the attack of cattle, especially of such as are in any way enfeebled. Although the usual station of the condor is mountainous, it often descends, as we have said, to feed among the plains and valleys; and a female, now in the French museum, was found at sea, sitting on the dead body of a floating whale. It breeds amid the inaccessible peaks of the Andes, making no nest, but depositing its eggs upon the arid rock. It is a large bird, of from three to four feet in length, with an extent of wing very variously stated, but probably sometimes reaching from ten to twelve feet. The female is of a much browner hue, and wants the caruncles. She is less in size than the male, an unusual circumstance in this order, although we suspect that the greater bulk of that sex is a feature chiefly characteristic of the hawks and eagles.

"In riding along the plain," says Sir Francis Head, "I passed a dead horse, about which were forty or fifty condors; many of them were gorged and unable to fly; several were standing on the ground devouring the carcass;

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[1] On the modern groups into which this family is divisible, the reader may consult a paper by Mr Vigors in the *Zoological Journal*, No. viii. p. 368.

[2] *Vultur*, Linn. Cuv.; *Cathartes*, Illiger, Temm.

[3] Nuttall's *Manual of Ornithology*, i. p. 36.

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the rest hovering above it. I rode within twenty yards of them; one of the largest of the birds was standing with one foot on the ground, and the other on the horse's body; display of muscular strength as he lifted the flesh, and tore off great pieces, sometimes shaking his head and pulling with his beak, and sometimes pushing with his leg. Got to Mendoza, and went to bed. Wakened by one of my party who arrived; he told me, that seeing the condors hovering in the air, and knowing that several of them would be gorged,[1] he had also ridden up to the dead horse, and that as one of these enormous birds flew about fifty yards off, and was unable to go any farther, he rode up to him; and then, jumping off his horse, seized him by the neck. The contest was extraordinary, and the rencontre unexpected. No two animals can well be imagined less likely to meet than a Cornish miner and a condor, and few could have calculated, a year ago, when the one was hovering high above the snowy pinnacles of the Cordillera, and the other many fathoms beneath the surface of the ground in Cornwall, that they would ever meet to wrestle and 'hug' upon the wide desert plain of Villa-Vicencia. My companion said he had never had such a battle in his life; that he put his knee upon the bird's breast, and tried with all his strength to twist his neck; but that the condor, objecting to this, struggled violently, and that also, as several others were flying over his head, he expected they would attack him. He said, that at last he succeeded in killing his antagonist, and with great pride he showed me the large feathers from his wings; but when the third horseman came in, he told us he had found the condor in the path, but not quite dead."[2]

The king-vulture, *S. papa* (Plate CCCLXXXVIII. fig. 3), is a much more gaily adorned species, the fleshy portions of its head and neck being red, orange, and purple. The upper parts of the plumage are of a pale reddish-white or clay colour, the collar at the base of the neck is bluish-gray, the quill-feathers and tail black (the former with paler edgings), and the under parts of the body white. This beautiful bird is found in America, from the 30th degree of north latitude, to about the 32d in the southern hemisphere; that is, it occurs in Mexico, Paraguay, Guiana, Brazil, and Peru; but most abundantly beneath the torrid zone. According to Azara, it makes its nest in hollow trees, and lays two eggs. It is supposed to derive its name from its habit of driving off the common vultures of America, called turkey buzzards, from their prey. The female king-vulture is of somewhat smaller size than the male. The ruff, and all the upper parts of her plumage, are brownish black, and her bill is destitute of caruncles.

Genus Cathartes, Illiger. Bill much more slender than in the preceding genera; the upper mandible inflated above the nostrils, encroaching as it were upon the forehead, curved at the point, the margins nearly straight; the under mandible slender, slightly inflated, and obtuse at the terminal portion. Cere extended. Nostrils broad, quadrangular, longitudinal, very open. Head and neck naked, without caruncles. Tongue fleshy, fringed. Tarsi naked, rather feeble; claws short, curved, blunt. Tail-feathers twelve.

This genus, as now restricted, is likewise confined to America. It consists of two species, the common turkey buzzard (so called in the United States), *C. aura*, Plate CCCLXXXVIII. fig. 2, and the carrion-crow (of the same country), *C. atratus*. The former is abundant both in North and South America, and extends, in the central districts of the fur-countries, as far north as the 54th degree. It is partially migratory, even in the middle states, retiring southwards on the approach of winter. A few remain throughout the year in Maryland, Delaware, and New Jersey; but none are known to breed in any of the Atlantic States to the north of the one last named. In the interior, however, they reach a much higher latitude during their summer migrations, probably owing to the greater heat of that season in the inland districts. A few make their appearance on the banks of the Saskatchewan when the month of June is far advanced, and after all the other summer birds have arrived and settled in their leafy arbours. Though gregarious in more southern countries, where they fly and feed in flocks, towards their northern limits seldom more than a pair are seen together. They feed on carrion, which they discover at a great distance, it is now said, by the sense of sight alone. They sometimes eat with such gluttonous voracity as to be unable to rise from the ground. They have been accused of attacking pigs, beginning the assault by picking out their eyes. But Mr Waterton, during his residence in Demerara, could not ascertain that they destroyed even living reptiles. He killed lizards and frogs and placed them in their way, but they took no notice of them till they began to emit a putrid effluvia. He differs from Mr Audubon in his ideas regarding the relative superiority in these birds of the organs of sight and smell. The one thinks the *eyes* have it, the other the *nose*. The turkey buzzard hatches her eggs in some swampy solitude, on a truncated hollow tree or excavated stump or log, laying them on the rotten wood. This species roosts at night on trees, but more seldom than the other kind in flocks. In winter they sometimes pass the night in numbers on the roofs of houses in the suburbs of the southern cities, probably induced to do so by the warmth which emanates from the chimneys. On fine clear days, even in the winter season, they amuse themselves by soaring majestically into the air, rising rapidly in large gyrations; and ascending beyond the thinnest fleecy clouds, they almost disappear from mortal view. In South America they will sometimes accompany the condor in his loftiest flights, rising, all fetid though they be, above the region of the purest Alps; and thus exhibiting an emblem of the mind of man, so often sunk in Epicurus' sty, yet for a time so raised by god-like genius, as not seldom to perceive "far off the crystal battlements of heaven."

The other species of this genus is the black vulture, or carrion-crow of the United States, *C. atratus*. It is rather less than the preceding, measuring about twenty-six inches in length, the general colour of the plumage dull black, with a dark cream-coloured spot on the primaries. It is more impatient of cold, and prevails chiefly about the larger maritime cities of South Carolina, Georgia, and Florida. They seem, from Mr Douglas's account, to proceed further north on the western side of the Rocky Mountains. Although they rise at times to a considerable elevation, their flight is less easy and graceful than that of the turkey buzzard. They are much more familiar, and in Charleston and Savannah may be seen walking the streets as demurely as domestic fowl. They sometimes become individually known; and a veteran with only one leg was observed to visit the shambles, and claim the bounty of a gentle butcher, for upwards of twenty years.

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[1] "The manner in which the Guachos catch these birds is to kill a horse and skin him; and they say that although not a condor is to be seen, the smell instantly attracts them. When I was at one of the mines in Chili, I idly mentioned to a person that I should like to have a condor: some days afterwards a Guacho arrived at Santiago from this person with three large ones. They had all been caught in this manner, and had been hung over a horse; two had died of galloping, but the other was alive. I gave the Guacho a dollar, who immediately left me to consider what I could do with three such enormous birds."

[2] *Rough Notes across the Pampas.*

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GENUS NEOPHRON, Sav. *Cathartes*, Illig. *Percnopterus*, Cuv. Bill long, slender, rounded, inflated at the curvature of the upper mandible, which is much hooked at the extremity. Nostrils median, oval, longitudinal, open. Cere covering two thirds of the bill. Face, cheeks, and throat naked, also a space extending down the middle of the neck. Tongue oblong, linear. Tail of fourteen feathers.

These birds are inhabitants of the ancient world. They are less powerful than the true vultures, and of smaller size, but are still more useful in their scavengerial functions, their love of putrid flesh, and of all impurities, being insatiable. The rachamach of Bruce, or gingi vulture of Sonnerat (*Neophron percnopterus*, Sav.), affords a characteristic example. See Plate CCCLXXXVIII. fig. 4. It is equal in size to a raven, the throat and cheeks naked, the feathers of the head and back of the neck long, narrow, and pointed. The plumage of the male is white, except the quill-feathers, which are black; that of the female and young is brown. This species has been described under a great variety of names. It occurs in several parts of Europe, more especially in Spain, Italy, and the Island of Elba. It is likewise widely distributed over Africa, where it is known to the Hottentots by the name of hougoop. It was held in great respect by the ancient Egyptians, and is frequently represented on the monuments of that mysterious people. It is said to follow caravans through the desert, for the sake of devouring every dead or unclean thing. We may add, that it has occurred once or twice in England.

GENUS GYPAETOS, Storr. Bill strong, straight, curved at the point, and somewhat inflated at the curvature. Cere basal, covered by strong bristly feathers pointing forwards. Nostrils oblique, oval, concealed by bristles. Tongue thick, fleshy, bifid. Head feathered. A tuft of bristly or hair-like feathers beneath the bill. Tarsi short, thick, feathered. Tail-feathers twelve.

This genus contains only a single species, the celebrated lammer-geyer, or bearded vulture of the Alps (*G. barbatus*). See Plate CCCLXXXVIII. fig. 5. It is one of the largest, or at least the longest-winged, of all the European birds of prey, haunting the highest mountains, and preying on lambs, goats, chamois, marmots, &c. Its strength and prowess are probably exaggerated, for although its powers of wing are undoubtedly great, its legs and talons are proportionally more feeble than those of eagles and falcons. It is said not unfrequently to secure its alpine prey by descending upon it suddenly with rushing wing, and driving it over a precipice, devouring the shattered limbs at leisure. It builds among inaccessible precipices, and lays two eggs. It is now one of the rarest of the birds of Europe, though formerly not uncommon among the mountains of Tyrol, Switzerland, and Germany. The peasant sportsmen of the last century often killed them, and one, Andreas Durner by name, is quoted by M. Michahelles as having shot sixty-five with his own hand. Though a bird of rare occurrence, the bearded vulture is very extensively distributed. In Europe it haunts the steeps of the Pyrenean Mountains, and the central Alps from Piedmont to Dalmatia; it is described by MM. Larey and Savigny as occurring in Egypt, and by Bruce as an inhabitant of Abyssinia; it has been received both from Northern Africa and the Cape of Good Hope, by M. Temminck; in Asia it is known to cast its cloud-like shadow over the vast steppes of the Siberian deserts; while not many years have elapsed since Professor Jameson received it from the snow-capped ranges of the Himalaya Mountains.

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The bird described by Bruce under the title of *Abou Duck'n*, or Father Long-Beard, is certainly identical with the lammer-geyer, although we have been sometimes puzzled to reconcile the comparatively feeble feet of the beautiful series submitted to our examination by Professor Jameson, with the meat-bearing prowess of the Abyssinian instance. On the loftiest summit of the mountain of Lamallon, while the traveller's servants were refreshing themselves after the fatigues of a toilsome ascent, and enjoying the pleasures of a delightful climate and a good dinner of goat's flesh, a lammer-geyer suddenly made his appearance among them. A great shout, or rather cry of distress, attracted the attention of Bruce, who, while walking towards the bird, saw it deliberately put its foot into a pan containing a huge piece of meat prepared for boiling. Finding the temperature, however, somewhat higher than it was accustomed to among the pure gushing springs of that rocky and romantic region, it suddenly withdrew, but immediately afterwards settled upon two large pieces which lay upon a wooden platter, and transfixing them with its talons, carried them off. It then disappeared over the edge of a "steep Tarpeian rock," down which criminals were sometimes thrown, and whose mangled remains may be supposed to have first induced the bird to select the spot as a place of sojourn. The traveller, in expectation of another visit, immediately prepared his arms, and it was not long before the gigantic creature re-appeared.

> As when a vulture on Imaus bred,
> Whose snowy ridge the roving Tartar bounds,
> Dislodging from a region scarce of prey,
> To gorge the flesh of lambs or yeanling kids
> On hills where flocks are fed, flies towards the springs
> Of Ganges or Hydaspes, Indian streams;
> But on his way lights on the barren plains
> Of Sericana, where Chineses drive
> With sails and wind their cany waggons light:—

So landed with far-stretched fanning pinions our lammer-geyer, within ten yards of his expected savoury mess, but also within an equal distance of Bruce's practised rifle, which instantly sent a ball through its ponderous body, and the magnificent bird sunk down upon the grass, with scarce a flutter of its outspread wings.

We may here close our brief notice of the first great family of the raptorial order, merely remarking farther, that the species last alluded to, though not so regarded by any of our systematic writers, appears to us to bear a great resemblance to the kites.

FAMILY II.—FALCONIDÆ.

This extensive family corresponds to the ancient unrestricted genus *Falco*, now greatly subdivided by modern naturalists, but not yet very satisfactorily arranged.[1] It contains a vast assemblage of eagles, hawks, buzzards, kites, &c., all characterized by a more or less curved bill, of which the upper mandible is strongly hooked; by obvious or open nostrils, pierced in an almost always naked cere; and by curved retractile pointed talons. The head is never bare of feathers, as in most of the preceding family, and the eye-brows are usually bony and projecting.

The geographical distribution of the Falconidæ, considered in their generality, is universal, one or more species being found in all known countries from Spitzbergen to

[1] The genus *Falco*, which in the days of Linnæus did not exceed thirty-two different kinds, amounts, in the last edition of Dr Latham's *Synopsis*, to 247. We have no doubt it now exceeds 300 species, even although many of Latham's names are reducible to the rank of synonyms.

Raptores.

New Holland, and several particular kinds having a very wide range, not only longitudinally across the whole temperate and northern parts of Europe, Asia, Africa, and America, but latitudinally through almost every clime. Most of them are, to a certain extent, migratory in their habits, although their movements are by no means so regularly periodical as are those of more laborious wing. In fact, the birds of this family, surpassing all others both in the duration and rapidity of their flight, are scarcely amenable to those natural laws which, in so many instances, appear to regulate or restrict the location of other tribes; and hence we find, that if a mural precipice, an insulated crag, the mouldering wall of a ruined castle, or the tortuous branch of some ancient and umbrageous forest tree, has been successfully sought for in spring as a secure retreat for the purposes of nidification and the rearing of their young, the other seasons of the year are usually spent in a life of wandering rapine. When we consider the facts which have been recorded of the flight both of hawks and pigeons, the migratory movements of birds in general become much less a subject of wonder (excepting always the beautiful instinct by which they are directed), than they would at first appear. It is well known that a falcon belonging to Henry II. of France, which had been carried to Fontainebleau, made its escape, and was retaken *next day* in the island of Malta, where it was recognised by the rings on its legs. According to Colonel Montagu, it must have flown with a velocity equal to fifty-seven miles an hour, supposing it to have been on wing the whole time. "But as such birds never fly by night, and allowing the day to have been at the longest, or containing eighteen hours of light, this would make seventy-five miles an hour. It is probable, however, that it neither had so many hours of light in the twenty-four to perform the journey, nor that it was retaken the moment of its arrival; so that we may fairly conclude that much less time was occupied in performing that distant flight." Another falcon having been sent from the Canary Islands to the Duke of Lermos, then in Andalusia, was found in Teneriffe *sixteen hours* after it had taken its flight from Spain. In regard to this instance the calculation is more simple, and less likely to prove erroneous, because, supposing the bird to have followed anything like a direct course, its flight from the coast of Andalusia to its native island would lie throughout over the waters of the ocean, and must therefore have been *continuous*. Now the distance being not less than 752 miles, that space divided by sixteen, the number of hours employed would give an average of forty-seven miles an hour for the whole course. At this rate, if a falcon were to leave the rock of Gibraltar on a Monday morning, it might enjoy eight hours repose, and yet reach Edinburgh Castle in the course of Tuesday forenoon. Pigeons have been shot in the far-inland forests of America with their stomachs full of fresh rice, which, to have resisted the digestive process, must have been swallowed *not many hours* preceding, but could not have been obtained within *eight hundred miles* of the place where they were killed.[1] It thus appears probable, that the most extended migratory movement which any species is required to perform, may in the greater number of cases be accomplished in a couple of days,—more frequently in the course of a few hours.

The numerous species by which this great family is constituted, though rarely adorned by those brilliant colours which characterize so many of the gentler tribes, are perhaps of all the feathered race the most remarkable for beauty of form and elegance of proportion. Their eyes are usually large and lustrous; their limbs, even when light, very strong and muscular, and armed with formidable claws with which they *pounce* their prey. Their general aspect (especially that of the true falcons), when compared with other birds, is well expressed by the word *noble;* and a single glance suffices to show that a combination of fierceness, energy, and courage, must form their predominating character. Like most other animals, however, whether human or brute, they are by no means insensible to kindness; and their instinctive sagacity, when directed by the skill and perseverance of man, has for ages been rendered subservient to his amusement in the sports of the field. But the princely art of falconry, whether from the progress of agriculture, the consequent minuter subdivision of land, and the increase of inconvenient barriers by the fencing of enclosed grounds,—or the tastes of men of rank and fortune having followed in another direction, has now almost entirely fallen into disuse. The species most generally trained for the purpose in this country appears to have been the peregrine falcon, but many other kinds are used in eastern regions; and even ponderous eagles are sometimes made subservient to the human will. Few things indeed more strongly illustrate the subduing influence of reason over instinct, than that a coarse illiterate groom, by tossing up a shapeless lure, should thus entice a proud rejoicing falcon from his airy height, and render him so submissively obedient as to forsake his soaring flight, and all his bright survey of field and river, and close contentedly his yet unwearied wings, to perch for hours upon a brawny arm, his lustrous eye encapped in velvet hood, and limbs "by jessies bound."

Raptores.

We must be very brief in our indications of the minor groups; and of several subgenera, as they are called, we can do nothing more than give the names. We do not here adopt the division of noble and ignoble birds of prey, which we deem a distinction without a difference, seeing that some of the long-winged hawks are difficult to train, while several of the short-winged kinds are made with ease submissive to the human race.

The genus DAPTRIUS of Vieillot (*Caracara*, Cuv.) is formed by the *Falco aterrimus* of Temm. (*Pl. Col.* 37 and 342). The cheeks and front of the throat are bare of feathers. The cere is haired. The adult plumage of the species named is black, with a white band spotted with black at the base of the tail; the bare portion of the face is flesh-coloured, the cere and legs yellow, the bill lead-coloured. The total length is about fifteen inches. It occurs in Guiana and Brazil. Its habits are unknown.

The genus IBYCTER of the same author (*Caracara*, Cuv.) has the cere smooth, and the upper part of the neck, as well as the cheeks, bare of feathers. The stomach is also bare and prominent. The tarsi are short, strong, and reticulated. We believe there is only a single species of this genus also, the *Ib. leucogaster* of Vieillot (*Gal.* pl. 6), or *Falco formosus* of Latham. Its bill is feeble, and but slightly hooked, and its habits offer a corresponding nonconformity with the usual manners of the raptorial order. It is of a mild and peaceable nature, living, it is said, chiefly on fruits and seeds, with the addition of a few insects, such as ants and locusts. It builds on trees, and utters from time to time a harsh discordant cry. It inhabits Guiana and Brazil, and, exhibiting some of the habits of the toucans, is called by the negroes the *capitaine des gros becs*.

The genus CARACARA, Cuv. (*Polyborus*, Vieil.), has the face only partially naked. The *C. Braziliensis* (Plate CCCLXXXVIII. fig. 6) is extremely common in Paraguay.

[1] Geese are also known to have been shot in Newfoundland with their crops full of maize, a species of corn which does not grow but at an immense distance from that island.

Raptores. It lives in pairs, flies rapidly, and preys on birds and small quadrupeds, as well as on insects and reptiles. The female is said to build upon the ground when in the pampas, and on trees when located in wooded countries. This accommodating habit is known to prevail among many other birds.

The three preceding genera, which some regard as forming the *tribe of Caracaras*, are all native to the new world, and may be said to form a link with the vultures, both in regard to the bareness of the face, and their alleged tendency to prey on carrion.

We now proceed to the *tribe of eagles*, of which the bill is very robust, comparatively straight at its basal and middle portion, and suddenly curved at the extremity. It includes the species most celebrated for their strength and courage. Their strong limbs, curved talons, and broad expansive wings, enable them to carry off well-grown lambs, and other bulky prey. They are therefore dreaded by shepherds and such pastoral people, as robbers of the first rank, and a high premium is placed upon their heads accordingly.

In the genus AQUILA properly so called, the bill is shorter than the head, straight, curved at the tip, the edge of the upper mandible with a slight festoon; the nostrils are oblong and oblique; the cere haired; the tarsi short, and covered with feathers. The well-known golden eagle (*A. chrysætos*) affords a characteristic example. This fine British species is widely spread over Europe and America. In our own country it builds on the ledges of mountain precipices—on the Continent its nest is frequently found in forests; for example, in that of Fontainebleau. It is common in the northern and central parts of Europe, but rarer in the south. It is, however well known in Italy. We have seen it sailing over the deep basin of the vale of D'Uomo d'Ossola, and high above the highest snowy peaks which glitter around the majestic passes of the Simplon. In America it breeds among the subalpine districts which skirt the Rocky Mountains, being seldom seen farther eastward. It is regarded by the aborigines as an emblem of strength and courage, and the Indian warrior as well as the highland chieftain glories in his eagle plume. These birds sometimes soar to a vast height, but they seem to do so rather as a kind of sporting exercise, than with a view to search for prey. When employed in hunting, they keep far nearer the earth, sweeping up the valleys, and skirting the sides of heath-covered mountains. The golden eagle is becoming rarer in Scotland every year. Many ancient eyries are pointed out to travellers by gray-haired shepherds, where the bird itself is now no longer known, and in no lengthened period we may expect its extirpation. Several other kinds of feather-footed eagles are known to naturalists, such as the *Aquila imperialis*, a common Egyptian species, not unfrequent in the eastern countries of Europe,—and the *Aquila Bonelli*, a recent acquisition, native to the mountains of Sardinia, and no doubt inhabiting other alpine lands. *Aquila fucosus* is a New Holland species, very common near Port Jackson, and remarkable for its fine wedge-shaped tail.

In the genus HALIÆTUS, or sea-eagle, the bill is nearly as long as the head, and the tarsi are bare of feathers, except at the top. Their habits resemble those of the eagles proper, but they prey more on fish, and will feed more readily on tainted flesh. Species occur in Europe, Asia, Africa, America, and Australia. Our own white-tailed eagle (*H. albicilla*, Plate CCCLXXXVIII. fig. 8) affords a good example. "On observing a person walking near their nests," says Mr Macgillivray, "they fly around him at a respectful distance, sailing with outstretched wings, occasionally uttering a savage scream of anger, and allowing their legs to dangle, with outspread talons, as if to intimidate him. I have observed them thus occupied, when on the edge of a precipice five hundred feet high, with a very steep slope above me, bounded by rocks, and from which I could not have made my escape had the birds been resolute. Although on such occasions they are in general extremely cautious, notwithstanding their manifest anxiety for the safety of their young, yet I once saw an eagle come within an hundred yards, when it was brought down with buckshot by a friend whom I had accompanied to the place."[1] The same writer observes, that he has never heard of the sea-eagle attacking those employed in robbing its nest; but that he has been credibly informed of its having attempted to molest individuals whom it chanced to find among its native crags, in perilous places. In the Hebrides it is itself frequently assailed by the skua-gull; and we have ourselves more than once seen it attacked by the raven. Raptores.

In our present group are many other species, such as the beautiful *Haliætus leucogaster* of New Holland, and the bald or white-headed eagle of America, *H. leucocephalus*. The latter is often seen sailing through and around the gigantic column of spray which rises from that "hell of waters," the cataract of Niagara. Though a bird of powerful wing, he seems to have fallen somehow into lazy habits, or at least prefers the produce of others' labours to his own. "Elevated," says Wilson, "on the high, dead limb of some gigantic tree, that commands a view of the neighbouring shore and ocean, he seems calmly to contemplate the motions of the various feathered tribes that pursue their busy avocations below,—the snow-white gulls slowly winnowing the air,—the busy tringæ coursing along the sands,—trains of ducks streaming over the surface,—silent and watchful cranes intent and wading,—clamorous crows,—and all the winged multitudes that subsist by the bounty of this vast liquid magazine of nature. High over all these hovers one whose action instantly arrests his whole attention. By his wide curvature of wing, and sudden suspension in air, he knows him to be the fish-hawk, settling over some devoted victim of the deep. His eye kindles at the sight, and balancing himself with half-opened wings upon the branch, he watches the result. Down rapid as an arrow from heaven descends the object of his attention, the roar of its wings reaching the ear as it disappears in the deep, making the surges foam around. At this moment the eager looks of the eagle are all ardour; and levelling his neck for flight, he sees the fish-hawk once more emerge, struggling with his prey, and mounting in the air with screams of exultation. These are the signals for our hero, who, launching into the air, instantly gives chase, and soon gains on the fish-hawk; each exerts his utmost to mount above the other, displaying in these rencontres the most elegant and sublime aërial evolutions. The unencumbered eagle rapidly advances, and is just on the point of reaching his opponent, when with a sudden scream, probably of despair and honest execration, the latter drops his fish:—the eagle poising himself for a moment, as if to take a more certain aim, descends like a whirlwind, snatches it in its grasp ere it reaches the water, and bears his ill-gotten booty silently away into the woods."[2] When forced to hunt for themselves, they often attack young pigs, lambs, and sickly sheep.

In the genus PANDION the bill is much shorter than the head; the tarsi are short and naked, covered all round with

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[1] *Rapacious Birds of Britain*, p. 60.

[2] *American Ornithology*, vol. i. p. 23. We quote Professor Jameson's *systematic edition*, in four small volumes (Constable's *Miscellany*, 1831). The student of American Ornithology will find some valuable notes by Sir William Jardine, in another Edinburgh edition, in three vols. large 8vo, 1832

Raptores.

imbricated scales; the claws are large and rounded on the under surface, the outer toe very versatile; and the second feather of the wing the longest. Our British osprey, or small fishing eagle, is the *Pandion haliætus*. It breeds in the vicinity of many of our northern sea-lochs, often on the chimney-top of ruined castles by the shore. It destroys a vast quantity of fish, which it secures by thrusting its talons through their backs during a sudden momentary plunge beneath the waves. It is remarkably abundant in North America; and Wilson observes that it permits the purple grakles to build their nests amid the interstices of the sticks of which it has framed its own. He adds, that it never picks up any fish which it may chance to drop either on land or water. We know not if this trait applies to those of the "old country." We once saw an osprey drop a large sea-trout, which it certainly did not attempt to recover; but then there happened at the same time to be an excellent shot, with a double barrel, within a rather dangerous distance of the same. The osprey occurs in New Holland, and is elsewhere very widely spread.

The genus CIRCÆTUS of Vieillot is in a manner intermediate between the fishing eagles, the ospreys, and the buzzards. We may mention as an example the bird called *jean-le-blanc* by the French (*F. Gallicus*, Gmelin), a common continental species.

In HARPYIA, Cuv. the bill is very strong, and compressed, the upper mandible dilated on the margins, and much hooked. The head is crested, the tarsi thick, the wings rather short. The harpies are large birds of prey, which dwell chiefly in the forests of Guiana, making their nests on trees, and committing great depredations. The largest is the *H. destructor* of Daudin (Plate CCCLXXXVIII. fig. 7), said to be capable of cleaving a man's skull by a single blow of its beak. We doubt if any one ever tried. However, it carries off young fawns, and sloths of a year old. It is a rare bird, lately imported to the Zoological Gardens of London, and well exemplified by the specimen in the Edinburgh Museum.

In the genus MORPHNUS of Cuv. (*Spizætus*, Vieillot), the wings are shorter than the tail, the tarsi are lengthened (in some feathered), and the toes feeble. The species are extremely beautiful, and richly varied in their markings. They are chiefly found in South America. We have figured as an example (see Plate CCCLXXXVIII. fig. 9) the *Morphnus cristatus* (*F. Guianensis*, Daud.), which strongly resembles the great harpy just mentioned in its general aspect, but is at once distinguished by its smaller size and longer tarsi. We may mention as an instance of those with plumed tarsi, the *Falco cristatellus* of Temm. *Pl. Col.* 282, which is a native of India and Ceylon.

In CYMINDIS, Cuv. and Temm. the tip of the upper mandible forms a lengthened curve, with a very acute point. The nostrils are obliquely cleft, almost closed; the cere narrow. The tarsi are very short, and reticulated; the wings rather long. The species are South American, and we know of nothing remarkable in their habits. See *Cymindis uncinatus*, Illiger, *Pl. Col.* 103. The extremely hook-billed species (*C. hamatus*, *Pl. Col.* 61) now forms the genus ROSTRHAMUS. Its nostrils are rounded, the space before the eye is bare, and the tarsi are scutellated. Its habits are unknown.

Naturalists differ greatly in their distribution of the preceding genera. Mr Swainson thinks *Circætus* is a subgeneric form of *Gypogeranus*, and he places *Cymindis* with the Caracaras, and certain other groups, in his sub-family *Cymindinæ* or kites, and locates *Morphnus* (*Spizætus*, Vieil.) with the buzzards.

We now proceed to a *third tribe*, consisting chiefly of the sparrow-hawks and goshawks. The bill is curved almost from the base, convex, the upper mandible dilated on the sides, the lower short and obtuse. The nostrils are nearly oval; the tarsi rather long and slender; the claws broad and sharp. The wings have the fourth feather the most extended, and are shorter than the tail. The species are numerous, and occur in all parts of the globe. The larger, which are also proportionally the more robust, with thicker tarsi and shorter wings, have by many Ornithologists been considered as constituting a separate genus, to which the name of ASTUR is applied. That rare British bird the goshawk (*Astur palumbarius*) may be named as a good example, while the smaller and more slender kinds included in the genus NISUS are represented by our sparrow-hawk (*N. communis*, the *Falco nisus* of Linn.). The transition from one to the other is however very gradual, and some deem their separation unwarrantable. Even the two British species, though usually regarded as the types of their respective sections, do not differ so much as to render the propriety of their separation very apparent, even were no other species known. They are all extremely active, as daring as the true falcons, and prey exclusively on living objects, which they seize with admirable dexterity. Their flight is generally low, and as they pass over the fields or woods, they dart upon their prey, whether it be in the air, among branches, or couched upon the ground.[1] The goshawk, though a short-winged species, was formerly held in great estimation for the purposes of falconry. It is one of the most generally diffused of all the accipitrine birds, but is now very rare in Britain. A beautiful white species (*Astur albus*) is found in New Holland. Of the sparrow-hawks we shall allude merely to the *Nisus musicus* of Africa, commonly called the chanting falcon. It is the only raptorial bird in any way gifted with the powers of song; but we must not suppose that its notes at all resemble the harmonious tones of the nightingale, or those of even our less accomplished songsters. Its voice is merely a little clearer than usual, although it seems impressed with a high idea of its own powers, and will sit for half a day perched upon the summit of a tall tree, uttering its incessant cry.

A *fourth tribe* contains the *kites*, which are likewise subdivided into several minor groups, all agreeing in their comparatively feeble bills and feet, their short tarsi, and long extended wings. The tail is forked. They are gifted with great powers of flight, but are neither strong nor courageous, seldom pounce on heavy game, sometimes contrive to prey on fish, and have never the slightest objection to chickens.

In the genus MILVUS of Cuv. is included our common kite (*M. regalis*, Vieil.; *Falco milvus*, Linn.). The tarsi are scutellated in front, and tolerably strong. This beautiful bird is rare in many districts of Scotland, and is scarcely ever seen in the Lothians. We have received it from Argyllshire, but do not think it occurs in the Western Isles. We have often, in the North of England, admired its wheeling flight, circling through the air with no perceptible motion of its long expanded wings, and sailing over that enchanting land of lakes and mountains, with such majestic sweeps as if it were itself "sole king of rocky Cumberland." The kite is distributed over all Europe, but is unknown in America. Other species of the genus occur in Asia, Africa, and New Holland.

In the genus ELANUS of Savigny the tarsi are very short, reticulated, and half clothed with feathers. The wings are long, the tail but slightly forked. It contains *F. dispar* and *melanapterus*, two species which some regard as one and the same. They feed on small birds, insects, and reptiles, and occasionally devour dead animals.

[1] *Rapacious Birds*, p. 231.

Raptores.

If identical, the species must exist in America, Africa (occasionally in Europe), and the East Indies. The swallow-tailed kite (*M. furcatus*) forms the genus Nauclerus of Vigors. See Plate CCCLXXXIX. fig. 1. The form is slender, the tail very long and greatly forked. The species just named is white, with back, wings, and tail black, glossed with green and purple. It inhabits America, at least as far south as Buenos Ayres, and also passes the summer and breeds in the warmer parts of the United States. Tempted by the abundance of the fruitful valley of the Mississippi, a few are seen to wander as far as the Falls of St Antony, in the forty-fourth degree. Audubon states, that in calm warm weather they soar to an immense height, pursuing the large insects (probably libellulæ) called musquito hawks, using their tails with an elegance peculiar to themselves, and performing the most singular evolutions. The Mississippi kite (*F. plumbeus*, Latham) constitutes the genus Ictinia of the modern systems. It is of a blackish ash colour, the head and under parts of a much paler ashy hue. Wilson frequently observed this hawk in the course of his perambulations, sailing about in easy circles, at a considerable height in the air, and generally in company with Turkey buzzards, with whose mode of flight its own exactly corresponds. It is not easy to say why two birds, whose food and manners are in other respects so different, should so frequently associate in their airy gambols. Though the Mississippi kite feeds chiefly on reptiles and insects, it is a bold and energetic bird. The specimen obtained by Wilson, though wounded, and precipitated from a stunning height, exhibited great strength, and a most unconquerable spirit. He no sooner approached to pick it up, than the bird immediately gave battle, striking rapidly with its claws, wheeling round and round as it lay, "partly on his rump," and defending itself with vigilance and dexterity. Notwithstanding all the aggressor's caution, it struck its hind claw into his hand, with such force as to penetrate into the bone. "Anxious to preserve his life, I endeavoured gently to disengage it; but this made him only contract it the more powerfully, causing such pain that I had no other alternative but that of cutting the sinew of his heel with my penknife." The whole time he lived with Wilson he seemed to watch his every movement, erecting the feathers of his head, eyeing him with fierceness, and no doubt regarding him (and with some show of justice) as the greater savage of the two.

In a *fifth tribe* we may place the honey-hawks, buzzards, and harriers, small groups connected, in a variety of ways, by the usual interlacements, with several of the preceding tribes. The buzzards, for example, both in form and plumage, resemble small eagles, though their bills are more curved from the base;[1] the harriers in some measure connect the buzzards with the accipitrine hawks (gen. *Nisus* and *Astur*); while the honey-hawks (*Pernis*) unite the buzzards to the kites. The natural affinities of groups are in truth so multiplied and complex, that we need scarcely wonder that even those who have most devoted themselves to explore such Cretan labyrinths, should have often failed in their supposed elucidation:—so much the worse for those who have never found the thread.

In the genus Pernis, Cuv. the lore, or space between the bill and eye, is closely covered by small, compact, rounded feathers, the nostrils are narrow, and the tarsi short, stout, and reticulated. The British bee-hawk (*P. apivorus*), or honey-buzzard as it is usually called, though it cares less for the honey than for those that make it, is of this genus. We have no other indigenous, or indeed European species; but a beautiful crested kind (*P. cristata*, Cuv.), Plate CCCLXXXIX. fig. 2, occurs in Java and the East Indies. *P. Ellioti* is also native to the latter country.

Raptores.

In the genus Buteo, Bechstein, the cutting margin of the upper mandible is more flexuous or tooth-like, the gape wider, and the space between the eye and the cere is covered by the same setaceous plumage which usually prevails in that part, the nostrils are rounded, and the tarsi scutellated in front. The buzzards are a numerous genus, distributed over most parts of the world. We have only two British species, the common buzzard (*Buteo vulgaris*), and the rough-legged kind (*B. lagopus*). The latter is a rare or rather accidental visitor, its proper districts being the northern parts of Europe and America. We think buzzards are most abundant in wooded countries. They fly more sluggishly than hawks, and generally rather low, but at times they ascend to a great height, sweeping round in easy circles, and uttering a frequent shrilly cry.

In the genus Circus the bill is slender and compressed, the cere large, the cheeks encircled by a kind of recurved ruff, and the tarsi long, slender, and scutellated before and behind. We have three British species, the moor harrier (*C. æruginosus*), the common ringtail or hen-harrier (*C. cyaneus*, male,—*C. pygargus*, female), and Montagu's harrier (*C. cineraceus*). All these birds roost and breed upon the ground, fly low, and frequent mountainous or marshy places. They prey upon whatever small-sized creatures they can master, whether beast, bird, reptile, or insect. The hen-harrier is supposed to occur in almost all parts of the world, but the identity of the American and European specimens has not been definitely determined. We have figured a foreign species as an example in Plate CCCLXXXIX. fig. 5. It is the *Circus palustris* of Temminck (*C. superciliosus* of some other authors), and a native of Brazil.

We now arrive at the falcons properly so called, or those which have been sometimes distinguished by the appellation of *noble birds of prey*, probably on account of certain members of the group, such as the peregrine and jer-falcon, being held in high esteem as accessaries in the sports of the field. We cannot say that we have been led to our present arrangement by an impression that it is more natural than any other, for we have already left the point which would have conducted us more insensibly into the ensuing nocturnal group of owls; but we do not think it is liable to more grave objections than are many others. Indeed the circular or recurrent nature of the actual affinities of natural groups renders their true exposition, so far as any consecutive system is concerned, impossible; for, instead of advancing, we must necessarily terminate where we began, and therefore either retrace a portion of our circle, or break or bend it, before we can proceed to another. Without, therefore, desiring the reader to suppose that the harriers in any special way conduct him to the falcons, we shall give a brief notice of the latter.

The falcons are chiefly distinguished by the strong, tooth-like notching of the bill, which in the preceding groups is either entirely absent, or shows itself only in the form of a more or less distinct festoon.[2] The first quill-feather is always long, the second longer than the third and fourth, so that the wing acquires a sharp or pointed form, instead of the rounded outline of the so-called ignoble tribes; and the points of the wings, when closed, usually attain to the end of the tail.

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[1] Mr Macgillivray mentions, that the digestive organs of the common buzzard so greatly resemble those of the golden eagle, that a figure of the one might serve for that of the other.

[2] It is, we believe, in vain that naturalists attempt exceptionless precision in their generalities; for, in this very group, the jer-falcon, in one sense the *noblest* of all, frequently wants the tooth, and exhibits a bill festooned like the eagle's.

Raptores.

In the restricted genus FALCO, then, the bill is short, but strong, conical, curved from the base, sharply hooked at the extremity, and almost always toothed as well as pointed; the nostrils are rounded, the cere bare, or merely encroached upon by the bristly feathers of the lore. The tarsi are rather short and strong, and covered with scales of somewhat variable form, but usually rounded or angular. The wings are long and pointed. We have four well-known British species, the peregrine falcon (*F. peregrinus*), the hobby (*F. subbuteo*), the merlin (*F. æsalon*), and the kestril (*F. tinnunculus*). Besides these, we may name the jer-falcon (*F. islandicus*, Plate CCCLXXXIX. fig. 4) as an occasional, and the orange-legged hobby (*F. vespertinus*) as an accidental visitor. The jer-falcon, in spite of its alleged want of teeth, is one of the boldest and most powerful of the class. This fine species seems now confined almost entirely to the most northern parts of Europe and America. It is well known in Iceland and Greenland, and was often seen by Dr Richardson during his journeys over the "barren grounds" of North America, where it preys habitually on ptarmigan, not, however, despising plovers, ducks, and geese. "In the middle of June," he observes, "a pair of these birds attacked me as I was climbing in the vicinity of their nest, which was built on a lofty precipice on the borders of Point Lake, in latitude 65½°. They flew in circles, uttering loud and harsh screams, and alternately stooping with such velocity that their motion through the air produced a loud rushing noise; they struck their claws within an inch or two of my head. I endeavoured, by keeping the barrel of my gun close to my cheek, and suddenly elevating its muzzle when they were in the act of striking, to ascertain whether they had the power of instantaneously changing the direction of their rapid course, and found that they invariably rose above the obstacle with the quickness of thought, showing equal acuteness of vision and power of motion. Although their flight was much more rapid, they bore considerable resemblance to the snowy owl."[1] Upon the whole, we think that Great Britain and Ireland are just as well quit of such a fierce intruder. The Doctor adds, that when the jer-falcon pounces down upon a flock of ptarmigan, the latter endeavour to save themselves by diving instantly into the loose snow, and making their way beneath it to a considerable distance.

A few species, in which the toothing of the upper mandible is double, form the genus BIDENS of Spix, synonymous, we presume, with *Harpagus* of Vigors. Such are *F. bidentatus*, Lath., *F. diodon*, Temm. *Pl. Col.* 198. In IERAX of Vigors, the upper mandible seems as strongly and sharply bidentated as in the preceding, but the under one is simply notched, as in the true falcons, and the second quill-feather of the wing is the longest. This genus includes the beautiful little finch-falcon of Bengal, *F. cærulescens*, the smallest of the hawk tribe. An elegant crested kind from Pondicherry serves as a type to the genus LOPHOTES.

We shall conclude this section by a brief indication of that remarkable bird, the secretary, or serpent-eater of Southern Africa—the *Gypogeranus serpentarius* of Illiger (see Plate CCCLXXXIX. fig. 9). Its affinities have been in no way satisfactorily illustrated, and each author has hitherto placed it according to his own fancy. Baron Cuvier locates it between the buzzards and the owls; M. Lesson makes it a "gallinaceous accipiter," in strange company with the horned screamer (*Palamedea cristata*) of Brazil; while Mr Swainson is now satisfied that it is no other than "the rasorial type of the aquiline circle." Be this as it may, it has a strong, well-curved bill, a crested head, a lengthened neck, and long, slender, crane-like legs. It is the only one of its genus, and has been designated by a variety of names. Some call it the messenger, because it runs with great rapidity, which few actual messengers ever do; others name it the secretary, because it has a pen-like plume behind its ear, where a secretary's pen should never be; while its frequent title of serpent-eater is probably better earned, by its useful habit of devouring those dangerous reptiles. Its diet, however, seems to be of a rather miscellaneous nature, as Le Vaillant found in the stomach of a single specimen twenty-one young tortoises, three snakes, and eleven lizards, besides which there was a large ball in the stomach, formed entirely of the scales of tortoises, the vertebræ of snakes and lizards, the legs of locusts, and the wing-cases of coleopterous insects. "In his habits," says Mr Bennet, "he partly resembles both the eagle and the vulture, but differs from them most completely in the nature of his prey, and in his mode of attacking it. Like the former, he always prefers live flesh to carrion; but the food to which he is most particularly attached consists of snakes and other reptiles, for the destruction of which he is admirably fitted by his organization. The length of his legs not only enables him to pursue these creatures over the sandy deserts which he inhabits, with a speed proportioned to their own, but also places his more vulnerable parts in some measure above the risk of their venomous bite; and the imperfect character of his talons, when compared with those of other rapacious birds, is in complete accordance with the fact, that his feet are destined rather to inflict powerful blows than to seize and carry off his prey. When he falls upon a serpent, he first attacks it with the bony prominences of his wings, with one of which he belabours it, while he guards his body by the expansion of the other. He then seizes it by the tail, and mounts with it to a considerable height in the air, from which he drops it to the earth, and repeats this process until the reptile is either killed or wearied out; when he breaks open its skull by means of his beak, and tears it in pieces with the assistance of his claws, or, if not too large, swallows it entire. Like the eagles, these birds live in pairs, and not in flocks; they build their aiery, if so it may be termed, on the loftiest trees, or, where these are wanting, in the most bushy and tufted thickets. They run with extreme swiftness, trusting, when pursued, rather to their legs than to their wings; and as they are generally met with in the open country, it is with difficulty that they can be approached sufficiently near for the sportsman to obtain a shot at them. They are natives of the south of Africa, and appear to be tolerably numerous in the neighbourhood of the Cape, where, it is said, they have been tamed to such a degree as to render them useful inmates of the poultry-yard, in which they not only destroy the snakes and rats which are too apt to intrude upon those precincts, but even contribute to the maintenance of peace among its more authentic inhabitants, by interposing in their quarrels, and separating the furious combatants who disturb it by their brawls."[2]

Raptores.

SECT. II.—NOCTURNAL BIRDS OF PREY.

The great raptorial division called owls are usually distinguished by the comparative largeness of their heads, the anterior portion of which is surrounded by a peculiar circle of feathers forming a facial collar, to which they owe the most marked and peculiar feature of their physiognomy. The bill is curved almost from the base, where it is greatly enveloped by setaceous feathers, which fre-

[1] *Fauna Boreali-Americana*, part ii. p. 28.

[2] *Tower Menagerie*, p. 211.

Raptores.

quently cover or conceal the cere and nostrils. The eyes are large, and so placed that vision is directed rather forwards than laterally, and are furnished with a nictitating membrane. The tarsi, and even the toes, are closely covered by short downy or hairy feathers. The outer toe is versatile; the claws extremely sharp. The plumage is remarkable for its great softness. The concha of the ear is for the most part very large; and from this we may infer that the sense of hearing is acute.

The greater proportion of the species hunt by night, or during the sweet but sombre hours of twilight. Their flight is light, buoyant, noiseless, and performed by slow but regular flapping of the wings. Their food, like that of most birds of prey, is various; but we believe they prefer mice and similar small quadrupeds, probably because the habits of these minute creatures are, like their own, nocturnal. Owls are solitary, seldom more than a pair being found together, although the woodcock owl (*Otus brachyotus*) is found during autumn in small conjoined family flocks of ten or twelve together; and the Arkansa owl of America is likewise in a manner gregarious. "There is something," says Wilson, "in the character of the owl so recluse, solitary, and mysterious, something so discordant in the tones of its voice, heard only amid the silence and the gloom of night, and in the most lonely and sequestered situations, as to have strongly impressed the minds of mankind in general with sensations of awe and abhorrence of the whole tribe. The poets have indulged freely in this general prejudice; and in their descriptions and delineations of midnight storms, and gloomy scenes of nature, the owl is generally introduced to heighten the horror of the picture."

The systematic arrangement of these nocturnal birds of prey is as yet unsatisfactory. The following is a brief view of Baron Cuvier's system.

The genus Otus has two well-marked aigrettes, or tufts of feathers, on the front of the head, capable of being depressed or raised at pleasure, and the conch of the ear extends semicircularly from the beak almost to the top of the head, and is furnished in front with a membranous opercle. Two British species may be here placed, the long-eared or horned owl commonly so called (*Strix otus*), and the short-eared owl (*Strix brachyotus*). The genus Ulula consists of species resembling the preceding in the bill and auditory opening, but not possessed of aigrettes. Such is the great northern species (*S. Laponica*, Gm.). The genus Strix properly so called has also large ear-openings, and wants the aigrettes, but is distinguished by the bill being comparatively straight at the base, and curved towards the extremity. The facial disk is strongly marked, the tarsi are feathered, and the toes are haired. Example, *Strix flammea*, our barn or white owl. In the genus Syrnium, the facial disk is formed of decomposed or unwoven feathers, the collar is also large, and the aigrettes wanting, but the toes are feathered. See Plate CCCLXXXIX. fig. 6. The brown or wood owl of Britain (*S. aluco* and *stridula*, Linn.) is placed here. The genus Bubo has the facial disk less marked, the aigrettes conspicuous, and the toes feathered. The great eagle owl of Europe (*B. maximus*, *S. bubo*, Linn.) affords a good example. It inhabits the larger forests of Russia, Hungary, Germany, and Switzerland, becoming very rare in France, disappeariug altogether in Holland, and visiting Great Britain as it were by chance. Here also may be placed the great horned owl of America, *S. Virginiana* (Plate CCCLXXXIX. fig. 8), which occurs in almost every quarter of the United States, and spreads into the far fur-countries of the north, wherever there is timber of sufficient size to serve the purposes of nidification. His favourite residence, however, according to Wilson, is the dark solitudes of deep swamps, covered by a growth of gigantic timber, from whence, so soon as evening darkens, and the human race retire to rest, he sends forth his unearthly hootings, startling the way-worn traveller by his forest fire, and "making night hideous." "Along the mountainous shores of the Ohio, and amidst the deep forests of Indiana, alone, and reposing in the woods, this ghostly watchman has frequently warned me of the approach of morning, and aroused me by his singular exclamations, sometimes sweeping down and around my fire, uttering a loud and sudden *waugh o! waugh o!* sufficient to have alarmed a whole garrison. He has other nocturnal solos, no less melodious, one of which very strikingly resembles the half-suppressed screams of a person suffocating or throttled, and cannot fail of being exceedingly entertaining to a lonely benighted traveller in the midst of an Indian wilderness."[1] The genus Noctua consists of species in which the tufts or aigrettes are wanting, the concha of the ear small, with an ordinary-sized opening. The facial disk is likewise small and incomplete. This gives the countenance a more hawk-like physiognomy; and in accordance with this expression, we find the habits of the species naturally more diurnal than those of many other owls. We here place the northern *Harfang*, or great snowy owl (*Strix nyctea*, Linn.), one of the most beautiful of the group, an occasional visitant of Great Britain, and not very unfrequent in the Orkney and Shetland Islands. It is a common inhabitant of the arctic regions of both the old and new world, from which it migrates on the approach of winter, but without passing to the southward of the colder portions of the temperate zone. It frequently hunts by day; and indeed if it did not so, what would become of it in those far northern countries where a "sleepless summer of long light" knows not for months the refreshing influence of nocturnal darkness? It preys not only on quadrupeds and birds, but frequently strikes its talons into fish, and bears them astonished from their moist abode into the leafy recesses of the forest. There are few things more out of place than a trout on the top a large tree. Its own flesh is said to be white and well flavoured; and when in good condition, is eaten both by the native Indians and the white residents in the fur-countries. Several of the smaller owls are included in the present genus, such as *Strix passerina*, Linn. In the genus Scops (Plate CCCLXXXIX. fig. 7) the toes are naked, and the head furnished with tufts; and in certain peculiar foreign species of considerable size, the tarsi (a very unusual character) are bare and reticulated. These have been formed of late into a genus called Ketupa. Example, *Strix Ketupa*, Horsfield, Temm. *Pl. Col.* 74.

One of the most curious of owls, in its habits, is the burrowing species of the new world—*Strix cunicularia* of Bonaparte. Its particular genus has not yet been determined. These birds inhabit the burrows of the marmot, and consequently dwell in open plains. They seem to enjoy even the broadest glare of the noon-day sun, and may be seen flying rapidly along in search of food or pleasure during the prevalence of the cheerful light of day. They manifest but little timidity, allow themselves to be approached sufficiently close for shooting, and though some or all may soar away, they settle down again at no great distance. If further disturbed, they either take a more lengthened flight, or descend into their subterranean dwellings, from whence they are dislodged with difficulty. When the young are only covered with down, they frequently ascend the entrance to enjoy the warmth of the mid-day sun; but as soon as they are approached, they quickly retire within their burrow. In North America the burrowing owl feeds

[1] *American Ornithology*, i. p. 101.

Insessores. chiefly on insects—in the West Indies (if the species are identical), on rats and reptiles.

Order II.—INSESSORES or PERCHING BIRDS.[1]

This is the most numerous order of the class of birds, and, as Cuvier has observed, is distinguished chiefly by negative characters; for it embraces all those various groups which, sometimes possessing but little in common, are yet in themselves neither raptorial, scansorial, grallatorial, natatorial, nor gallinaceous. At the same time they exhibit a general resemblance to each other in structure, and present such gradual transitions from group to group, as to render definite subdivisions by no means easy.

They are said to possess not the violence of birds of prey,—meaning thereby our preceding accipitorial order. Yet a fly-catcher crushing the body of a slender-limbed and delicate gnat, a blackbird pertinaciously dragging a reluctant worm from its subterranean dwelling, or a sparrow with his bill as full of tortuous caterpillars as it can contain (to say nothing of the butcher-bird, which is said to impale his prey alive upon "the blooming spray"), is assuredly as raptorial or predaceous as need be well desired. Neither can the division of the smaller birds into granivorous and insectivorous be strictly maintained, though we doubt not that the strong, conical billed species eat most greedily of seeds and grain, while those of softer and more slender bill are chiefly avidous of insect life;—but all precise divisions, founded on the love of any special diet, must be received with reservation,—seeing that almost all passerine birds feed both themselves and young in spring and early summer with what may be correctly called animal food (that is, insects and worms), while in autumn and throughout the winter season they just as generally (and for the best of reasons) have recourse to all manner of seeds and grain. The tender-billed birds are certainly more dependent on insect food than the others, and it is consequently among them that we find the greater proportion of our migratory species; for as the increasing chillness of autumn depopulates the busy world of insect life, so our finest songsters (the familiar red-breast forming a delightful exception) take then their departure for other climes, not so much by reason of the immediate influence of cold upon themselves, as because they find their accustomed food becoming daily less abundant. Such of the insectivorous tribes as remain with us throughout the year assuredly combine the graminivorous diet with their more favourite food, just as the hard-billed species sustain themselves during spring and summer by the capture of insects. In tropical countries, where the seasons are less strongly or differently marked, and the death-like torpidity of our northern winters is unknown, this periodical change of food may probably either not obtain, or be less perceptible in its occurrence; but as we know that over a great part of the globe it is true, that for one portion of the year most insect-eating birds feed on seeds, and that for another portion of the year most seed-eating birds feed on insects, we may be permitted to doubt the propriety of rigorously dividing the great body of passerine species into insectivorous and granivorous sections. We admit that, either from the nature of things, or the feebleness of human language, the terms applied to the greater divisions of natural history ought not to be construed according to their strictest literal interpretation, as they are frequently of a conventional character, and have in some cases been substituted for numerical signs, as more easily held in remembrance; but it is nevertheless to be greatly desired, that those who are influential in the nomenclature of science should avoid bestowing appellations which convey an erroneous idea of the objects intended to be expressed. Insessores.

The feet of the insessorial order are especially formed for perching, the hind toe springing from the same plane as the anterior ones,—a structure which gives them great power in grasping. Their legs or tarsi are always of moderate length, and the claws not strongly curved. The form of the bill is too various to be generalized; and the same may be said of the length of the wings, of which the comparative breadth generally bears relation to the habit of life of each particular tribe. The stomach is in the form of a muscular gizzard, generally preceded by a greater or less expansion in the shape of crop, and there are usually two very small cæca. The lower larynx is very complicated, especially among the various tribes of songsters. We must now rest satisfied with these brief and barren generalities. "The great order of Passeres or Insessores of authors," Mr Macgillivray observes, "is so heterogeneous in its composition, that all who have attempted to characterize it, whether in few or in many words, have utterly failed; for this plain reason, that its various groups are as unlike to each other as they are to the Raptores or Rasores, and that in fact the only common features which they exhibit are those of the general organization of birds. A hornbill and a humming-bird, a parrot and a wren, a kingfisher and a swallow, a starling and a toucan, not to mention others still more dissimilar, are surely as unlike each other as a hawk and a shrike, a pigeon and a plover, or a flamingo and a pelican."[2]

The first principal division of the passerine birds consists of those genera in which the external toe is united to the internal by not more than one or two of the joints, and contains the four great tribes of *Dentirostres*, *Fissirostres*, *Conirostres*, and *Tenuirostres*.

Tribe 1st.—Dentirostres.

Bill with a marginal notch towards the extremity of the upper mandible.

The dentirostral tribe is composed chiefly of insectivorous groups, and, according to the modern views, contains the following five families, viz. *Laniadæ*, *Merulidæ*, *Sylviadæ*, *Ampelidæ*, and *Muscicapidæ*. We do not think the general reader, with whose tastes the treatises in our Encyclopædia are for the most part made to conform, would be benefited by our entering into the complexities of these circular arrangements, or by an extended exposition of the innumerable minor groups of which the families are composed. We shall therefore here content ourselves by noticing the principal generic groups which form as it were the groundwork on which the more elaborate systems have been erected, and with which it is necessary to become familiar in their more general and comprehensive form, before their minuter subdivisions (to be elsewhere studied) can be understood. The genera are chiefly determined by the form of the bill, which is strong and compressed among the shrikes and thrushes, depressed in the fly-catchers, rounded and thickish in the tanagers, slender and pointed in the warblers,—but in each and all exhibiting different degrees of the typical character, or a tendency to transition, which admits of various systematic views.

Mr Swainson divides the Laniadæ or shrikes into five sub-families, viz. *Lanianæ*, or true shrikes; *Thamnophilinæ*, or bush-shrikes; *Dicrurinæ*, or drongo shrikes; *Ceblepyrinæ*, or caterpillar catchers; and *Tyranninæ*, or tyrant shrikes; and each of these contains a great variety of ge-

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[1] Picæ and Passeres, Linn.

[2] *British Birds*, vol. i. p. 311.

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nera and subgenera. We shall here follow the outlines of Baron Cuvier's system, which we shall illustrate by occasional figures.[1]

In the genus LANIUS, the bill is of moderate size, but strong, somewhat triangular at the base, and laterally compressed. In the European species (which we call butcher-birds) the upper mandible is somewhat arched. Three of these (*Lan. excubitor*, *colurio*, and *rufus*) are natives of England, but the first and last are very rare. The food of butcher-birds consists chiefly of insects, but they attack occasionally the smaller kinds of birds and quadrupeds. Their mode of flight is irregular, the tail being kept in constant agitation. The sexes differ from each other in their plumage, and the immature birds bear a resemblance to the adult females. In most of the species the moult is single, in others double, that is, certain parts of the plumage are changed twice a year. Our great cinereous shrike (*L. excubitor*) destroys its larger prey by strangulation, and transfixing it after death upon a thorn, tears it into smaller parts at leisure. This wise but somewhat savage instinct seems implanted in the bird to make amends for the comparative weakness of its feet and claws. "This singular process," says Mr Selby, "is used with all its food. I had the gratification of witnessing this operation of the shrike upon a hedge accentor (*A. modularis*) which it had just killed; and the skin of which, still attached to the thorn, is now in my possession. In this instance, after killing the bird, it hovered with the prey in its bill for a short time over the hedge, apparently occupied in selecting a thorn fit for its purpose. Upon disturbing it, and advancing to the spot, I found the accentor firmly fixed by the tendons of the wing at the selected twig. I have met with the remains of a mouse in the stomach of a shrike; and Montagu mentions one in which he found a shrew."[2]

We have figured, in illustration of the genus Lanius, the species called *fiscal* (*L. collaris*) by Vaillant. See Plate CCCXC. fig. 1. When this bird sees a locust, mantis, or small bird, it springs upon it, and immediately impales it on a thorn, with such dexterity, that the spine always passes through the head. It is a bold, vindictive, noisy, and even cruel bird, for it seems to kill many more victims than it actually requires for food. These are found transfixed on many a neighbouring bush and tree, the major part often so destroyed by dryness as to be totally unfit for food.

Some foreign species, in which the upper ridge of the bill is straight, and the point only curved, form the genus THAMNOPHILUS of Vieillot. The Thamnophili inhabit chiefly the tropical regions of the new world, but some of the species have an extensive range, from Canada as far southwards as Paraguay. In *Tham. guttatus* of Spix the bill is very strong, and the inferior mandible inflated. In others it is straight and slender, with its base adorned with reversed setaceous feathers. Such is *L. plumatus*, an African species, which forms the genus PRIONOPS of Vieillot.

In the genus VANGA (Plate CCCXC. fig. 3) the bill is large, greatly compressed throughout, the point of the upper mandible suddenly curved, the under mandible bent upwards. Example, *Lan. curvirostris*, Gmelin. In OCYPTERUS, Cuv. the bill is conical, rounded, scarcely arched towards the point, the termination very sharp and fine, slightly notched. The legs are rather short, and the wings long, from which characters the species have obtained the name of swallow butcher-birds; but they are as courageous as other shrikes, and do not fear to attack even crows. The species are numerous along the shores and islands of the Indian Seas, where they exhibit great agility in the capture of their insect prey. Ex. *Lan. leucorhynchos*, Gm. In BARYTA of Cuv. the bill is large, conical, straight, round at the base, and encroaching on the forehead by a circular notch; the ridge is rounded, the sides compressed, the point curved. The nostrils are small and linear. The species of this genus, as well as those of Vanga, are by some combined with the crows, as part of the conirostral tribe. We may name, as an example, the piping grakle of the older writers (*Coracias tibicen*, Lath.), a native of New Holland, where it is known by the name of *Jarra-war-nang*. It preys on small birds, and is said to have a melodious voice, resembling the tones of a flute. The genus CHALYBÆUS, Cuv. has the bill resembling the preceding, but rather thicker at the base, and the nostrils are pierced in a broad membranous space. See Plate CCCXC. fig. 6. The species are natives of New Guinea, and are remarkable for their beautiful tints of burnished steel. *C. paradisæus* has the feathers on the head and neck like frizzled velvet, and was first described by Sonnerat as a bird of paradise,—*Par. viridis*, Gmelin. In PSARIS of Cuvier the bill is conical, thick, round at the base, but not encroaching on the front, slightly compressed, and curved at the extremity. The genus is founded on the Cayenne shrike of Latham, *Lanius Cayanus*, Linn.[3] It now contains many species, all classed by Mr Swainson among the Muscicapidæ or fly-catchers. Their habits are said to resemble those of the butcher-birds. The genus GRAUCULUS, Cuv. has the bill less compressed than in Lanius, the upper ridge sharp, equally curved throughout its whole extent, the commissure or cutting edges also slightly bent. The hairs which sometimes cover the nostrils ally these species to the crows, from which they are distinguished by the notching of the bill. Their prevailing hues are ash-colour, and they are native to the Indian islands. Cuvier here places the beautiful *Irena puella* of Dr Horsfield, a Javanese species, of a fine velvet black, the back splendid ultramarine blue. It is ranged by others with the Orioles. To the same genus he likewise refers the Papuan and New Guinea crow (*C. papuensis* and *Novæ Guineæ*), and the *Piroll* of Temminck, of which the male and female differ so remarkably, the former being of a glossy blue, the latter greenish. This last species forms the genus *Ptilonorhynchus* of Kuhl,—*Kitta* of M. Lesson. It is the satin-bird of the colonists of Port Jackson, a solitary, fearful creature, which seldom leaves the cover of the umbrageous woods. The Australian natives call it *cowry*.

In BETHYLUS, Cuv., the bill is thick, short, bulged, slightly compressed towards the end. Its type is the magpie-shrike of Latham, *L. picatus*, an inhabitant of Guiana and Brazil. Plate CCCXC. fig. 2. In FALCUNCULUS the bill is much compressed, almost as high as long, the culmen arched. It contains the *Lanius frontatus* of New Holland. The genus PARDALOTUS (which M. Lesson places with the tit-mice, and Mr Swainson with the manakins) is likewise constituted by a New Holland species, the *Pipra punctata* of Shaw. The bill is short, obtuse, convex, and slightly compressed.

All the preceding genera of the dentirostral tribe are supposed by Baron Cuvier to be more or less allied to *Lanius* of Linnæus. A great diversity of opinion, however, exists regarding their natural distribution; and in the most recent systems they will be found differently

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[1] For more minute details, the student may consult Mr Swainson's "Inquiry into the Natural Affinities of the Laniadæ or Shrikes," *Zoological Journal*, No. iii. p. 289.

[2] *Illustrations of British Ornithology*, vol. i. p. 149.

[3] See *Zool. Journal*, No. vii. p. 354, and No. viii. p. 483.

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and variously disposed, according to the views of each particular author.

Many of the genera next ensuing are more allied to the fly-catchers, *Muscicapidæ;* but not a few are classed by recent writers among the *Laniadæ* and *Ampelidæ*. The bill is of medium size, broad at the base, horizontally depressed, almost straight, generally wider than high, the point more or less hooked and notched. The mouth is garnished with bristly feathers projecting forwards. Their food varies according to their size and strength,—the more powerful species seizing occasionally on small birds as well as insects, the more feeble being satisfied with the latter kind of prey.

In the genus TYRANNUS, Cuv., the bill is straight, lengthened, strong, the culmen rounded, the point suddenly hooked. See Plate CCCXC. fig. 5. The species consist chiefly of Linnæan fly-catchers, with a few shrikes. They are all native to America, and, as their name implies, are fierce and domineering in their disposition. They will defend their young against the boldest aggressor, and have been seen to drive from their nesting-places even the largest birds of prey. As an example, we may here name the king-bird, or tyrant fly-catcher, of the new world, *T. intrepidus*. This species is one of the most remarkable for the boldness and intrepidity which he displays in his attacks on the strongest of the feathered race. During the earlier months of summer, indeed, his life is one continued scene of broil and battle. According to Wilson, hawks and crows, the bald eagle, and the great black eagle, all equally dread an encounter with this dauntless creature, who, as soon as he perceives a bird of prey, however powerful, in his neighbourhood, darts into the air, and quickly ascending above his supposed enemy, pounces with violence upon his back, and continues his attack till his own domains have been departed from. He is likewise in some measure obnoxious to the human race, on account of his love of bees; for he will take post on a fence or garden-tree in the vicinity of hives, and make continual sallies on the industrious tenants, as they pass to and from their never-ceasing labours. His great American biographer, however, is of opinion, that whatever prejudice may prevail against him for such depredations, he is on the whole greatly the friend of man, by destroying multitudes of insects, whose larvæ prey on the produce of the field and garden. The tyrant has been immortalised in verse as well as prose:

> Far in the south, where vast Maragnon flows,
> And boundless forests unknown wilds enclose,
> Vine-tangled shores and suffocating woods,
> Parch'd up with heat, or drown'd with pouring floods;
> Where each extreme alternately prevails,
> And nature sad their ravages bewails;
> Lo! high in air above those trackless wastes,
> With spring's return the king-bird hither hastes;
> Coasts the famed gulf, and from his height explores
> Its thousand streams, its long indented shores,
> Its plains immense, wide opening on the day,
> Its lakes and isles, where feather'd millions play:
> All tempt not him: till gazing from on high,
> Columbia's regions wide below him lie;
> There end his wanderings and his wish to roam,
> There lie his native woods, his fields, his home;
> Down, circling, he descends from azure heights,
> And on a full-blown sassafras alights.
>
> Fatigued and silent, for a while he views
> His old-frequented haunts, and shades recluse;
> Sees brothers, comrades, every hour arrive,—
> Hears, humming round, the tenants of the hive;
> Love fires his breast,—he woos, and soon is blest,
> And in the blooming orchard builds his nest.

The king-bird migrates in summer at least as far north as the fifty-seventh parallel. It reaches Carlton House in the month of May, and retires southward in September. A new species has been of late years discovered on the banks of the Saskatchewan, but nothing is yet known of its habits. It is described by Mr Swainson under the title of *Tyrannus borealis*. It is considerably smaller than the preceding, and may at once be distinguished by its forked tail, not tipped with white.[1] The other species are numerous.[2]

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A still more extensive genus is that named MUSCIPETA, Cuv. The bill is long, much depressed, twice as broad as high even at the base, the culmen usually very blunt, the margins forming an oval curve, the point feebly notched, and the base covered by long, setaceous feathers. The general form of the species is feeble compared with that of the preceding, and they prey exclusively on insects. They are extremely beautiful, often adorned by crests upon the head, or by gracefully elongated feathers in the tail. The majority are native to Africa and India. The paradise fly-catcher of Le Vaillant may be named as an example.

In the genus PLATYRHYNCHUS of Desm., the bill is short, and still broader and more depressed than in the preceding. *P. cancromus* inhabits Brazil. These birds are by some conjoined with *Todus*, to which they are assuredly allied. Certain species, of which the feet and legs are long and slender, and the tail extremely short, form the genus CONOPHAGA of Vieillot. The fly-catchers properly so called, genus MUSCICAPA, Cuv., have the beard or bill-feathers less extended than in *Muscipeta*, and the bill itself is narrower, the ridge or culmen is distinctly marked, the margins straight, the point slightly bent. The species are peculiar to the ancient continent, and not more than four or five occur in Europe. Of these, two are British, *M. grisola*, or the spotted fly-catcher, a well-known and common species; and *M. luctuosa*, or the pied fly-catcher, which is very rare. We have seen it on the banks of the Eden in Cumberland. Both are birds of passage. The species of this genus take their insect prey upon the wing, darting upon it at intervals from some favourite twig. The males and females differ considerably in their markings, especially in spring and summer, although the former sex (at least in *M. albicollis*, Temm.) are scarcely to be distinguished from the latter throughout the winter season. The modifications in the form of the bill in this extensive genus have led to the formation, so far as concerns exotic species, of a vast number of sectional groups, or subgenera, the characters of which we cannot here detail.

We now arrive, in accordance with Baron Cuvier's system, though not, we fear, by natural transition, at the genus GYMNOCEPHALUS, of which the beak resembles that of *Tyrannus*, except that the ridge is more arched, and a great portion of the face is bare of feathers. See Plate CCCXC. fig. 8. There seems to be only a single species, commonly called the bald crow (*G. calvus*), a bird about the size of a rook, of a uniform tobacco-brown colour, the feathers of the wings and tail black. It is called *oiseau mon prère* by the Creoles of Cayenne, probably from its capucin aspect. Its bald front bestows upon it a very singular physiognomy. Vaillant regards the absence of feathers on that part as accidental; and he mentions in a note,[3] that he received a specimen from Cayenne, in which the face was plumed. But M. Lesson states that he has examined more than twenty specimens, and has always found the face unfeathered.

The genus CEPHALOPTERUS, on the contrary (see Plate

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[1] See *Fauna Boreali-Americana*, part ii. pl. lxxxv.
[2] Consult Mr Swainson's "Monography of the Tyrant Shrikes of America," *Journal of the Royal Institution*, No. xl.
[3] *Histoire des Oiseaux de Paradis*, t. i. p. 109.

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CCCXC. fig. 4), has the front adorned by a very peculiar tuft of feathers, which, rising upwards, and then spreading around and drooping downwards, shades the head, as it were, beneath a parasol. Another expanded and lengthened set of plumes hangs in an apron-like fashion from the breast. The prevailing plumage is deep black, the parts first mentioned having a metallic lustre. The bill of the only species known (*C. ornatus*) is robust, the mandibles nearly equal, the upper being convex, without notch, and scarcely bent at the extremity. This bird was *brought* to Paris, from the Lisbon Collection, by M. Geoff. St Hilaire, and was believed to have been sent originally from Brazil. As that country, however, has been so much explored without the Cephalopterus having ever since been met with, it is more likely, M. Temminck thinks, to have been obtained in the less-frequented countries of Peru, or the coast of Chili. On the other hand, M. Lesson alleges, that he was informed by a well-instructed Portuguese, that the bird in question came from Goa. It is the *Coracina cephaloptera* of M. Vieillot. We have no doubt it is a South American species.

From these singular birds we proceed to the Cotingas or chatterers, genus AMPELIS, Linn., a varied and beautiful family, now partitioned into several minor groups. They have all the depressed bill of the fly-catchers in general, but it is rather shorter in proportion, broadish, and slightly arched.

Those in which the bill is the strongest and most pointed, with dilated margins, are characterized by an insectivorous regime. These are the *piahaus* of South America, genus QUERULA, Vieil. The species fly in troops through the forests. Here are placed the *Cotinga rouge* of Vaillant, or *Ampelis phœnicia*, also the *Ampelis cinerea* and *Muscicapa rubricollis* of Gmelin. In the ordinary Cotingas (or genus AMPELIS properly so called) the bill is more feeble, little elevated, deeply cleft. The species inhabit moist places, and are remarkable for the rich and lustrous plumage of the males during the breeding season. We here place the *Ampelis pompadoura*, *carnifex*, and *cotinga*, Linn. In the genus BOMBYCILLA, Brisson, which includes our European or Bohemian chatterer, the head is ornamented by an elongated crest, and the majority of the species have the secondary feathers of the wings terminated by a small oval expansion, resembling a bit of scarlet sealing-wax. These birds prefer wild fruits to insects. The appetite of the American species (*A. Americana*) is stated by Mr Audubon to be of so extraordinary a nature as to prompt it to devour every fruit and berry in its way. In this manner it will gorge itself to such excess as to be sometimes unfit to fly, and may then be taken by the hand. "I have seen some which, though wounded and confined to a cage, have eaten apples until suffocation deprived them of life."[1] Our author adds, however, that they are also excellent fly-catchers, spending much of their time in pursuit of winged insects. They become very fat during the fruit season, and are then so tender and juicy as to be much sought for as an article of epicurean diet. They inhabit the United States throughout the year. The habits of the European wax-wing (*A. garrula*) are much less known. It not unfrequently visits Britain during winter, and is supposed to breed within the arctic circle. It likewise inhabits North America, but has not been observed to the southward of the fifty-fifth parallel. Dr Richardson observed a flock of three or four hundred on the banks of the Saskatchewan in May. During their trips to Britain they feed, when they can get them, on the berries of the mountain ash; and Sir William Jardine found the stomachs of one or two killed near Carlisle to be crammed with holly berries. A third species was some time ago discovered by Dr Seibold in Japan. It is the *B. phœnicoptera* of Temminck, and wants the wax-like appendages to the wings.

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In the genus CASMARHYNCHUS, Temm., the bill is remarkably broad, greatly depressed, soft and flexible at the base, of a harder consistence, and somewhat compressed towards the extremity. The nostrils are large and open, and placed far forward on the bill. As an example, we may name that singular bird the araponga (*Cas. nudicollis*, Temm. *Pl. Col.* 368–83), a Brazilian species, remarkable for the metallic resonance of its cry, which sounds like the clinking of a blacksmith's hammer. By reason of this peculiarity, it is known to the Brazilians by the name of *O. ferrador*, or the blacksmith. The adult male is pure white, the face and front of the neck nearly bare, of a green colour, sprinkled with a few small black feathers. The female is green, spotted on the under parts with white, the upper plumage of the head nearly black. The young at first resemble the mother, and adolescent males are found with a mingled plumage of green and white. Another species, of nearly corresponding plumage, is distinguished by a long, fleshy, sometimes slightly feathered caruncle, hanging from the basal front of the upper mandible. It is erectile, and sometimes projects upwards. This is the *Ampelis carunculata* of the older systematic writers. We presume it to be also the *Campanero* of the Spaniards, called *dara* by the Indians, and bell-bird by the English. "It is about the size of a jay," says Waterton. "His plumage is white as snow. On his forehead rises a spiral tube nearly three inches long. It is jet black, clothed all over with small white feathers. It has a communication with the palate, and when filled with air looks like a spire; when empty, it becomes pendulous. His note is loud and clear, like the sound of a bell, and may be heard at the distance of three miles. In the midst of these extensive wilds, generally on the top of an aged mora, almost out of gun reach, you will see the campanero. No sound or song from any of the winged inhabitants of the forest, not even the clearly pronounced 'Whip-poor-will,' from the goat-sucker, causes such astonishment as the toll of the campanero. With many of the feathered race, he pays the common tribute of a morning and an evening song; and even when the meridian sun has shut in silence the mouths of almost the whole of animated nature, the campanero still cheers the forest. You hear his toll, and then a pause for a minute; then another toll, and then a pause again; and then a toll, and again a pause. Then he is silent for six or eight minutes, and then another toll, and so on. Actæon would stop in mid chase, Maria would defer her evening song, and Orpheus himself would drop his lute, to listen to him, so sweet, so novel, and romantic is the toll of the beautiful snow-white campanero. He is never seen to feed with the other Cotingas, nor is it known in what part of Guiana he makes his nest."[2] In a third species (*Amp. variegata*, Gmel. *Pl. Col.* 51, Plate CCCXC. fig. 10) the front of the throat is all beset with numerous fleshy worm-shaped appendages. All these birds are vaguely said to feed upon insects, but on no authority that we can find. "Could we but know," says Mr Swainson, "the habits and economy of these singular birds, which, had they not been seen, might be thought fabulous, what an interesting page of nature's volume would be unfolded! Yet at present we only know that they live in the deepest and most secluded forests of tropical America, where they subsist upon an infinite variety of fruits unknown to Europeans. They are much oftener heard than seen, since their notes are particularly loud, and are ut-

[1] *Ornithological Biography*, vol. i. p. 227.

[2] *Wanderings in South America*, p. 121.

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tered morning and evening from the deepest recesses of the forests. We have sometimes caught a distant view of them, perched upon the topmost branches of the loftiest trees."[1]

In the genus PROCNIAS (now more restricted than by Hoffmansegg) the bill is likewise very broad, and deeply cleft, but the structure is firmer, and the upper mandible more convex. The nostrils are basal. Example, *P. ventralis*, Illiger, *Pl. Col.* 5.

In the not very closely allied genus CEBLEPYRIS, Cuv. which Mr Swainson classes as the most aberrant division of the shrikes, the bill resembles that of the Cotingas, but the shafts of the rump-feathers are sharp pointed. These birds inhabit chiefly Africa, and prey on caterpillars. Example, *C. phœnicopterus*, Temm. *Pl. Col.* 71.

The genus GYMNODERA, Geoff. (which forms a portion of the *Coracinæ* of Vieillot), has the bill stronger than in any of the preceding *Ampelidæ*, the neck is partially bare, and the head covered with velvety feathers. There does not seem to be more than one species (*G. nudicollis*), described by Shaw under the name of bare-necked grakle. It was classed by Gmelin and Latham as a crow,—the *Corvus nudus* of their respective works.

The Drongos (genus EDOLIUS, Cuv.) have the bill partially depressed and notched, and its upper ridge sharp; but it is distinguished by both mandibles being slightly arched through their whole extent, and the nostrils are covered with feathers. The species are rather numerous, and are characteristic of the tropical countries of the East. The Malabar shrike of Shaw (*Edolius remifer*, Temm. see Plate CCCXC. fig. 7) affords a good example. The position of this genus ought certainly to be in closer approximation to the *Laniadæ* than it is in the arrangement of Baron Cuvier. Their habits are insectivorous, and some of the species are said to warble as sweetly as the nightingale. They usually dwell together in society, pursue bees with great avidity, and are often seen to combine in large groups on the outskirts of the forests during morning and evening. The species we have figured is a native of Java and Sumatra.

In the genus PHIBALURA of Vieil. the ridge of the bill is arched, as in Edolius, but shorter, broad at the base, somewhat dilated laterally, and slightly notched. The only known species is a beautiful South American bird (*Ph. flavirostris*, Vieil.; *Ph. cristata*, Swain., *Zool. Illust.* pl. xxxi.), which appears to occur chiefly in the mining districts of Brazil. It was very rare a few years back, but has now become comparatively common in collections, in consequence of several recent importations.

We come now to an extensive group, the ancient Tanagers, genus TANAGRA of Linn., which, like most of the other genera, has in recent times been numerously subdivided. The bill is convex, sub-triangular at the base, the upper mandible slightly arched, curved at the point, notched, the margins flexuous and enlarged; the nasal fossæ are deep and large, and closed by a membrane; the nostrils are rounded. The wings are rather short. The Tanagers are characteristic of America. They feed both on grain and insects, and are remarkable for the beauty and brilliancy of their plumage. The following are the principal subdivisions. In EUPHONIA, Desm. (*Tangaras bouvreuils*, Cuv.), the bill is short, and exhibits, when viewed vertically, an enlargement at the base on either side. The tail is also short in proportion. Examples,—*Tan. violacea*, Lath.,—*Pipra musica*, Gmel.,—*Tan. diadémata*, Pl. Col. 243,—and *Tan. chlorotica*, Gmel. See Plate CCCXC. fig. 9. In the genus SALTATOR, Vieil. (*Tangaras grosbec*, Cuv.), the bill is conical, thick, inflated, as broad as high, the culmen rounded. Such are *Tan. magna*, *atra*, *flammiceps*, &c. In the restricted genus TANAGER (properly so called) the bill is short, though longer than in *Euphonia*, as broad as high, slightly compressed. Examples, *T. tricolor*, *thoracica*, *auricapilla*, &c. In the genus TACHYPHONUS, Vieil. (*Tangaras loriots*, Cuv.), the bill is more lengthened, conical, compressed, arched, sharp pointed. Examples, *T. cristata*, *nigerrima*, &c. In the genus PYRANGA, Vieil. (*Tangaras cardinals*, Cuv.), the bill is strong, lengthened, the point but slightly curved, the margin of the upper mandible often strongly toothed. The wings are rather long. The habits of several of the species of this genus are better known than those of the preceding, in consequence of their more hardy constitution, which enables them to spend the summer months in North America. One of the most beautiful of these is the scarlet tanager (*Tanagra rubra*, Linn.). Among all the birds that inhabit the woods of the United States, there is none, according to Wilson, that strikes the eye of a stranger, or even of a native, with so much brilliancy as this. Seen among the green leaves, with the light falling strongly on his plumage, he appears most beautiful. His whole plumage, with the exception of the wings and tail, is of the most vivid carmine red. The wing-coverts, posterior secondaries, and middle tail-feathers, are black, and form a rich contrast to the other portions of the plumage. After the autumnal moult the male becomes dappled with greenish yellow. The colour of the female is green above and yellow below; her wings and tail are brownish-black, edged with green. Though this lovely species sometimes builds in orchards, and visits cherry trees for the sake of their fruit, it does not frequently approach the habitations of man, but prefers the solitude of the umbrageous woods, where, in addition to fruits, its food consists of wasps, hornets, and humble-bees. The scarlet tanager comes just within the limits of the fur-countries, but is unknown as yet beyond the forty-ninth degree. His nest, placed upon the horizontal branch of a tree, is built of broken flax and dry grass, so thinly woven that the light is easily seen through it. The eggs are only three in number, of a dull blue, spotted with brown; but the bird is supposed to breed more than once a year. The genus Pyranga contains also *Tan. æstiva* and other species.

We conclude our notice of the Tanagers by a brief indication of the genus RAMPHOCELES, Vieil., of which the bill is strong, compressed, with the sides of the lower mandible so enlarged as to spread backwards towards the cheek. Such is *Tanagra Jacapa* of Gmelin, a South American species, represented in Plate CCCXCI. fig. 2.

Our next group consists of birds more or less allied to thrushes. In all, the bill is compressed and arched, but the upper mandible is but slightly hooked, and the notching feeble. As in other extensive assemblages of species, however, the structure is considerably varied. The natural regimen is mingled, consisting both of wild fruits, worms, and insects. A few species are gregarious, the majority solitary. Of ten or twelve kinds which inhabit Europe, we have six in Britain, viz. the missel-thrush (*T. viscivorus*), the song-thrush (*T. musicus*), the field-fare (*T. pilaris*), the red-wing (*T. iliacus*), the blackbird (*T. merula*), and the ring-ouzel (*T. torquatus*). The aspect and general habits of most of these are too familiar to require illustration. The blackbird and the thrush are two of our most delightful and accustomed songsters.

> When snow-drops die, and the green primrose leaves
> Announce the coming flower, the merle's note
> Mellifluous, rich, deep-toned, fills all the vale,
> And charms the ravished ear. The hawthorn bush,
> New budded, is his perch; there the gray dawn

[1] *Natural History and Classification of Birds*, vol. ii. p. 75.

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He hails, and there, with parting light, concludes
His melody. There, when the buds begin
To break, he lays the fibrous roots, and see
His jetty breast embrowned; the rounded clay
His jetty breast has soiled: but now complete,
His partner and his helper in the work,
Happy assumes possession of her home:
While he upon a neighbouring tree his lay,
More richly full, melodiously renews.

.....The thrush's song
Is varied as his plumes; and as his plumes
Blend beauteous, each with each, so run his notes,
Smoothly, with many a happy rise and fall.
Sometimes below the never-fading leaves
Of ivy close, that overtwisting binds
Some riven rock, or nodding castle wall,
Securely there the dam sits all day long;
While from the adverse bank, on topmost shoot
Of odour-breathing birch, her mate's blythe chaunt
Cheers her pent hours, and makes the wild woods ring.[1]

The missel-thrush is the largest and strongest of the genus, at least in Europe. He is a bold, pugnacious bird, guarding his nest with great success from the intrusive magpie. His song is loud and clear, but monotonous; something like an ineffectual attempt to combine the tones of the thrush and blackbird. Yet Colonel Montagu admired it greatly. The ring-ouzel affects mountainous and barren places. The field-fare and red-wing are only seen with us in winter, and are known to breed in the more northern parts of Europe. The former sings well, and we have somewhere seen it called the nightingale of Norway.

One of the most noted of the foreign species of the genus is the mocking-bird of America, *T. polyglottus*, Linn. It measures about nine inches in length, is cinereous above, whitish below, with the tips of the wing-coverts, the base of the primaries, and the lateral tail-feathers white. This unrivalled Orpheus and great natural wonder of the American forests inhabits the whole northern continent from the state of Rhode Island to the larger islands of the West Indies, and, continuing through the equatorial regions, is found as far south as Brazil. Neither is it confined to the eastern or Atlantic states, being known to exist in the wild territory of the Arkansa, more than a thousand miles from the mouth of Red River. It breeds around the far western sources of the Platte, near the very base of the Rocky Mountains; and Mr Bullock observed it on the table-land of Mexico. The mocking-bird may be regarded as a permanent (we mean stationary) inhabitant of the milder regions of the western world, though such as are bred to the north of the Delaware seem to move southwards before the approach of winter.[2] The period of incubation varies with the latitude. A solitary thorn, an almost impenetrable thicket, an orange tree, cedar, or holly bush, are favourite places; and during this important period neither man nor beast can approach without being attacked. Cats are especially persecuted; yet his chief and most vengeful rage is directed against the black snake, a mortal enemy. The male bird darts upon the insidious reptile with the greatest courage, and by violent and incessant blows upon the head, sometimes deprives him of life. The boasted fascination of his race, his lurid eye, his sharp envenomed fangs, avail not when competing with the love of offspring, that pure and beautiful affection, the least selfish of all instinctive feelings. "The plumage of the mocking-bird," says the first great historian of the American feathered tribes, "though none of the homeliest, has nothing gaudy or brilliant in it; and had he nothing else to recommend him, would scarcely entitle him to notice; but his figure is well proportioned, and even handsome. The ease, elegance, and rapidity of his movements, the animation of his eye, and the intelligence he displays in listening and laying up lessons, from almost every species of the feathered creation within his hearing, are really surprising, and mark the peculiarity of his genius. To these qualities we may add that of a voice full, strong, and musical, and capable of almost every modulation, from the clear mellow tones of the wood-thrush to the savage scream of the bald eagle. In measure and accent he faithfully follows his originals. In force and sweetness of expression he greatly improves upon them. In his native groves, mounted on the top of a tall bush or half-grown tree, in the dawn of dewy morning, while the woods are already vocal with a multitude of warblers, his admirable song rises pre-eminent over every competitor. The ear can listen to his music alone, to which that of all the others seems a mere accompaniment. Neither is this strain altogether imitative. His own native notes, which are easily distinguishable by such as are well acquainted with those of our various song birds, are bold and full, and varied seemingly beyond all limits. While thus exerting himself, a bystander, destitute of sight, would suppose that the whole feathered tribes had assembled together on a trial of skill, each trying to produce his utmost efforts, so perfect are his imitations. He many times deceives the sportsman, and sends him in search of birds that perhaps are not within miles of him, but whose notes he exactly imitates; even birds themselves are frequently imposed on by this admirable mimic, and are decoyed by the fancied calls of their mates, or dive with precipitation into the depth of thickets, at the scream of what they suppose to be the sparrowhawk."[3]

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The mocking-bird sometimes breeds in captivity. Many years ago a Mr Klein, of Philadelphia, partitioned off a space of twelve feet square within doors, lighted by a pretty large wire-grated window. In the centre he placed a cedar-bush, five or six feet high, in a box of earth, and scattered about a sufficient quantity of materials suitable for building. A male and female mocking-bird were introduced, and soon began to build. When the nest was completed the female laid five eggs, all of which she hatched, and she fed the young with great affection till they were nearly able to fly. Business, unfortunately, called the proprietor from home for a fortnight, and the care of the colony being left to the domestics, the result may be anticipated. On his return the young were utterly dead, and the parents nearly famished.

Several African species allied to our present group dwell together like starlings, in numerous chattering flocks, pursuing insects, and committing great depredations in gardens. Several are remarkable for the lustrous splendour of their plumage. Such are *Turdus auratus* and *nitens* of Gmelin. The Senegal species, called the glossy thrush, *T. æneus*, is characterized by the magnificent length of its caudal plumes. These richly attired species belong to the genus LAMPROTORNIS, Temm. Other species, in which the bill is slender and lengthened (as in the Brazilian thrush of Lath.), form the genus Ixos of the last-named author; while the genus ENICURUS (more nearly related, however, to the fly-catchers) consists of one or two species with a stronger bill, the tail long and forked. Such is *E. coronatus*, Temm. *Pl. Col.* 113; and *E. velatus*, ibid. 160, from Java. GRALLINA of Vieillot is constituted by a New Holland species with a straight, lengthened, rather rounded bill, and long legs. The plumage is black and white. Ex. *G. melanoleuca*, Vieil. The genus TRICHOPHORUS, Temm. is composed of species of which the bill is very strong, and garnished at the base with long, projecting bristles, which sometimes prevail also on the

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[1] Grahame's *Birds of Scotland.* [2] Nuttall's *American Ornithology*, i. 321. [3] Wilson's *American Ornithology*, ii. 92.

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occiput. The manners of these birds are as yet unknown. They live in Western Africa. Ex. *Tr. barbatus*, Temm. *Pl. Col.* 88.

The ant-thrushes, MYOTHERA, Illiger, come next in order. They are chiefly distinguished by their long, slender tarsi, and short tails. See Plate CCCXCI. fig. 1. The species of the ancient world, inhabitants for the most part of India, the eastern islands, and New Holland, are characterized by brilliant and contrasted colouring. These are the *Breves* of Buffon, the short-tailed crows of English writers. They form the genus PITTA of Vieillot and Temm., of which the bill is strong but thrush-like (*P. cyanurus*, *brachyurus*, &c.); while MYOTHERA, as now restricted, contains the American species, of much more sober plumage, with the bill more abruptly hooked, and the tooth stronger. The species dwell among the enormous ant-hills of the western world, keeping much upon the ground. They seldom fly, and certain kinds are remarkable for their deep sonorous voices. The largest, longest legged, and most singular in its general aspect, known under various names, such as long-legged crow, king-thrush, &c. (*Corvus grallarius*, Shaw; *Turdus rex*, Linn.), constitutes the genus GRALLARIA of the modern systems. It is a native of Guiana. The beautiful New Holland bird, with a bill like a thrush, but shorter, the legs long, the nails almost straight, and the lengthened tail-feathers terminated by sharp points, forms the genus ORTHONYX, and is placed by Cuvier immediately after the preceding group of ant-eating thrushes.

The genus CINCLUS, Bechstein, characterized by an almost straight, compressed, sharp-pointed bill, comprises our well-known water-ouzel, *C. aquaticus*. This interesting bird is frequent along the banks of rivers, but seems to prefer those of a somewhat rocky, alpine character. It lives in pairs, keeping always close by the stony margin of its chosen stream. The nest, according to Sir William Jardine, is formed exactly like that of our common wren, with a single entrance, and is composed of ordinary mosses, without much lining. It is usually placed beneath some projecting rock, not many yards above the water, "and often where a fall rushes over, in which situation the parent birds must dash through it to gain the nest, which they do with apparent facility, and even seem to enjoy it. At night they roost in similar situations, perched with the head under the wing, on some little projection, often so much leaning as to appear hanging with the back downwards. I recollect a bridge over a rapid stream, which used to be a favourite nightly retreat, under an arch; I have there seen four at a time sitting asleep in this manner, and used to take them with a light. Before settling for their nightly rest, they would sport in the pool beneath, chasing each other with their shrill and rapid cry, and at last suddenly mount to their perch; when disturbed, they return again in five minutes."[1] During winter they migrate to the lower streams; but in summer are most abundant on the alpine tributaries. They feed on small fish and insects, and are remarkable for their power of walking, with the assistance of their wings, beneath the surface. There is an American species (*C. Americanus*), of somewhat larger size, and of a uniform brownish slate colour. It extends along the range of the Rocky Mountains, from Mexico to Lake Athabasca. There is also an Asiatic species, figured by Mr Gould,[2] under the title of *C. Pallasii*, a name formerly bestowed on a bird supposed to come from the Crimea.

Mr Brehm has described another species by the name of black-bellied water-ouzel (*C. melanogaster*). It inhabits the north-eastern parts of the European continent, visiting in severe winters the coasts of the Baltic, where it is neither shy in its habits, nor distrustful of the presence of man. We are rather inclined, however, to distrust some of Mr Brehm's species.

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The genus PHILEDON of Cuvier has the bill slightly arched throughout its whole length, compressed, broadened at the base; the nostrils are large, protected by a cartilaginous scale, and the tongue terminates in a sort of tuft. Hence the species are by many classed among the honey-sucking or tenuirostral tribes. Many of them are remarkable for some particular garniture about the base of the bill, and are found in New Holland and the eastern islands. The genus is very extensive, but not very naturally composed, as it consists of species brought from a variety of other genera, such as *Certhia*, *Merops*, *Gracula*, *Sturnus*, &c. Some have a fleshy wattle depending from the lower mandible, as in *Phil. carunculatus* of New Holland (which forms the genus CREADON of Vieillot). In others the head is partially bare of feathers, as in the *goruk*, likewise a native of New Holland, a bold and restless bird, which feeds both on insects and honey, and often puts to flight whole droves of blue-bellied parrakeets. Some have neither bare skin nor wattles, but are distinguished by a peculiar frizzled character of parts of the plumage. The poe bee-eater of Cook's voyage (*Phil. Cincinnatus*) is of this kind. It is a beautiful bird, of a glossy blackish green, with a band of white across the upper portion of the wing, and a pendent tuft of long, twisted, white feathers on each side of the neck. It is a native of New Zealand, and was formerly in great request, as contributing to ornament the feathered mantles worn by chiefs and persons of distinction. The species is also said to sing well, and is moreover highly esteemed as an article of food.

In the genus EULABES, Cuv. (*Mainatus*, Brisson; *Gracula*, Vieil.), the bill is strong, compressed, high, the culmen arched, the sides dilated towards the gape. A portion of the cheek is bare, and a fleshy appendage stretches towards the occiput from either eye. Here are placed the famous mina birds, of which two species seem to have been confounded by Linnæus under the title of *Gracula religiosa*. The specific name was first applied by misapprehension, in consequence of a Musulman woman refusing, on account of some religious scruple, to allow a European artist to make a drawing of one of these birds, which she had in captivity. Some uncertainty seems still to pervade the naming of the species. The Indian kind (*G. Indicus*, Cuv.) is somewhat larger than a blackbird, the plumage of a fine silky black, with a white spot upon the central edge of the wings, the bill and feet yellow. This bird is easily tamed, and becomes extremely familiar in confinement. It is probably the most accomplished linguist of all the feathered tribes, and may be taught to pronounce long sentences in the most clear and articulate manner. It is consequently held in high esteem, and is frequently brought alive to European countries, although it must be confessed that the purity of the English tongue is not always exhibited by the result of its maritime education. The food of the mina in a state of nature is said to consist both of fruits and insects. It greatly loves bananas, and in this country has no objection to either grapes or cherries. The larger species (*G. Javanus*, Cuv.) equals the size of a jay. See Plate CCCXCI. fig. 3. The bill is broader, more hooked at the end, but without the notch. Now M. Lesson gives the name of *Sumatranus* to this species, and

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[1] Note to Wilson and Bonaparte's *American Ornithology*, vol. iii. p. 451.

[2] *Century of Birds from the Himalaya Mountains.*

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says that the Javanese, who esteem it highly, and part with it unwillingly, obtain it only by navigation. The Indian species he has named *Javanus*, but without assigning any special reason for such transmutations. The plumage is the same in both. Old Edwards seems long ago to have indicated the two kinds. "The greater minor," says he, "for bigness equals a jackdaw or magpie; the lesser hardly exceeds a blackbird, so that the one is at least twice as big as the other." The bird described by Bontius as an Indian starling was a mina. It imitated man's voice more accurately than a parrot, and "was oftentimes troublesome with its prattle."

In the genus GRACULA, Cuv. (*Pastor*, Temm.), the bill is compressed, straight, or but slightly arched, the notch feeble, and the commissures form an angle as in the starlings. This restricted genus contains several interesting species, such as the pagoda-thrush (*G. pagodarum*), so called from its frequent occurrence among the pagodas of Malabar and Coromandel. According to Sonnerat, it is often kept caged for the sake of its song. The paradise grakle of Latham (*Par. tristis*, Linn.) also pertains to this genus. It is well named *Gracula gryllivora* by Daudin, and is remarkable, as its name implies, for the destruction of locusts. We abridge the following particulars from Buffon. The island of Bourbon, where this species was formerly unknown, was once overrun to an alarming extent by locusts, which had been accidentally introduced from Madagascar. The governor-general and the intendant of the island, alarmed at the desolation which was taking place, deliberated on the best means of extirpation, and with that view they introduced several pairs of the so-called paradise grakle from India. The plan promised to be successful; but unfortunately some of the colonists observing the birds eagerly thrusting their bills into the soil of the newly-sown fields, imagined they were in quest of grain, and spread a report that the grakles, so far from proving beneficial, were likely to be highly detrimental to the country. The case was argued in due form. It was stated on the part of the grakles, that they ransacked the new-ploughed fields, not for grain, but insects; but the opposite view prevailed, and two hours after the edict of proscription passed, not a living individual was to be found in the island. A speedy repentance followed this intemperate and hasty execution, the locusts regained their ascendency, and soon becoming more injurious than ever, the grakles were again introduced, after an absence of nearly eight years. Their preservation and extension now became an affair of state, laws were enacted in their favour, and the physicians (we presume, from policy) declared their flesh unwholesome. An opposite inconvenience, however, is said to have since arisen. The birds having prodigiously increased in numbers, and being no longer adequately sustained by insect food, have had recourse to grapes, dates, and mulberries, and have even proceeded to scratch up rice, maize, wheat, beans, and other useful produce; they enter pigeon-houses, and attack both eggs and young; and thus, after destroying the destroyer, they have themselves become a greater pestilence than that which they extirpated. There is perhaps some exaggeration in the concluding parts of this statement, as M. Duplessin, who resided several years in the island, states that the laws for its preservation are still in force. We may add, that this bird is of the same lively and imitative disposition as the mina, and is easily taught to speak. When kept near a farm-yard, or other place resorted to by different kinds of creatures, it spontaneously acquires the various cries of dogs, ducks, geese, sheep, pigs, and poultry. The manners of the genus in general resemble those of the starling. They fly in troops, searching for insect prey; their habits are familiar, their docility remarkable, and their powers of imitation almost unparalleled. The only European species hitherto classed with the grakles is the beautiful rose-coloured ouzel (*P. roseus*), which occurs in several of the warmer countries of Asia and Africa, is not unfrequent in Spain and Italy, and shows itself in other parts of Europe, more rarely as we proceed northwards. Even in Tuscany and the Lombardo-Venetian territory it is esteemed unusual. A few are recorded to have built their nests in the Florentine district in 1739. We do not know that they have been since observed to breed in Europe. They were very common in Dalmatia in 1832; and in the year following one was shot in Ross-shire.

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In the genus PYRRHOCORAX, Cuv. the bill is compressed, arched, rather slender, slightly notched, the nostrils covered with feathers. We have two European species, according to Temminck's views, viz. the alpine crow of Latham (*P. pyrrhocorax*), and our own red-legged crow (*P. graculus*). The former inhabits the highest of the Northern and Helvetian Alps, seldom showing itself during the summer season at any distance from the regions of perpetual snow; the latter is also mountainous, but more widely spread over countries of less elevation. It is not unfrequent along many of the rocky coasts of England and Wales, is frequent in the Isle of Man, and occurs occasionally along the western shores of Scotland, and in Colonsay and other islands. Baron Cuvier places this bird alongside the hoopoes, as a tenuirostral genus called FREGILUS.

In the genus ORIOLUS the bill resembles that of the thrushes, but is more powerful. The legs are shorter, and the wings rather more lengthened. As now restricted, this genus contains only the species of the ancient continent, those of America (*Icterus*, *Cassicus*, &c.) being included among the conirostral tribes. The golden oriole (*Oriolus galbula*) is one of the most beautiful of European birds. It occurs occasionally in Britain. It breeds in many parts of the European continent, arriving in spring and departing in autumn. It builds on the tops of trees, its nest being attached to and partly suspended from a forked branch. This species feeds on fruits and insects, and is particularly fond of figs. The Italian peasants suppose its cry to signify "Contadino, é maturo lo fico?" Its own flesh is of most excellent flavour, especially in autumn, when having for a time fared sumptuously on the best of fruits, it has become extremely fat. The rich plumaged regent bird of New South Wales (*Sericulus chrysocephalus*, Swainson) is by some regarded as an oriole.

The genus GYMNOPS, Cuv. possesses the strong bill of the orioles, but a great part of the head is bare of feathers. In some of the species there is a prominence on the base of the beak. Such are the knob-fronted bee-eater of White[1] (*Merops corniculatus*), figured by Vaillant under the name of corbicalao (*Ois. d'Amérique et des Indes*, pl. 24), and the cowled bee-eater (*Merops monachus*, Latham). The tongue is said to be tufted like that of *Philedon*. To the genus Gymnops Cuvier also refers the bald grakle (*G. calva*, Linn. and Lath.), a remarkable species, native to the Philippine Islands, where it is said to build in the hollows of the cocoa-nut tree. It feeds on fruits, and is extremely voracious.

In the genus MENURA, Shaw, the bill is straight, somewhat triangular at the base, compressed, the nostrils lengthened, central. Region of the eyes bare. Feet large and strong. The only known species of this singular and somewhat anomalous genus, the lyre-tail of New Holland (*M. lyra* or *superba*), is characterized by the great extension and peculiar structure of the tail-feathers. (See Plate CCCXCI. fig. 4.) It is equal in size to a pheasant.

[1] *Voyage to Botany Bay*, p. 190.

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The general plumage is brown. The tail of the female is of the ordinary structure. This bird inhabits rocky districts. Though placed in its present station by Cuvier, it certainly seems more allied to the gallinaceous than the passerine order. Its history, however, is still obscure, and its anatomical structure, we believe, has not yet been investigated.

From the last-named genus, it would appear an abrupt and bold transition to the feeble-bodied, soft-billed stone-chats, warblers, wagtails, and other *Sylviadæ*, all of which, however, Baron Cuvier has here grouped as intermediate between *Menura* and *Pipra*. They form a very numerous assemblage, all characterized by a rather straight and slender bill, but varying, on the one hand, by the depression of the mandibles, towards the fly-catchers, and on the other, by its compression and curvature, towards the straight-billed butcher-birds. The Sylviadæ or warblers are divided by Mr Swainson into the five following sub-families, viz. 1st, *Saxicolinæ* or stone-chats, in which the bill is depressed at the base, the gape furnished with diverging bristles, the feet lengthened, the tail rather short, the head large; 2d, *Philomelinæ* or nightingales, in which the general structure is larger and more robust than in the typical warblers, and the feet more formed for perching; 3d, *Sylvianæ* or true warblers, of which the size is very small, the structure weak, the bill very slender, straight, with the under mandible much thinner than the upper; 4th, *Parianæ* or tit-mice (placed by Cuvier in the conirostral tribe), in which the bill is either entire or very slightly notched, and more or less conic, the hind toe large and strong, and the lateral toes unequal; 5th, *Motacillinæ* or wagtails, in which the bill is lengthened, straight, and slender, the legs long, and formed for walking, the hind toe elongated, and the tail narrow and lengthened.[1] Mr Swainson has elsewhere remarked, that the Sylviadæ might be termed "ambulating fly-catchers," since, when viewed collectively, they are only separated from the *Muscicapinæ* by a different mode of feeding, indicated by the superior length and structure of their feet,—these parts being adapted for constant locomotion, either among branches or upon the ground; while in the true fly-catchers the feet are short, small, and feeble, in accordance with the sedentary habits of the species. "Comparing the warblers, on the other hand, with the thrushes, we see that the best distinction between the two groups lies in the very character which assimilates the *Sylviadæ* to the fly-catchers, namely, the basal depression of the bill. We allude, of course, to typical examples; since all these distinctions are softened down, in proportion as the three groups approximate.[2] We shall now proceed with our exposition of Baron Cuvier's system.

The genus Saxicola, Bechstein, has the bill slightly depressed and broadened at the base. The species of this genus seem confined to the ancient continents and New Holland. They feed on insects, build on the ground or among heaps of stones, and usually frequent rather wild and barren places. We have three British species, the wheat-ear or white-rump (*S. œnanthe*), which is migratory, and arrives with us in early spring, frequenting commons and mountain pastures, but also occurring in more cultivated places, though always preferring open districts; the whin-chat (*S. rubetra*), likewise migratory, but later in its arrival, and frequenting moorlands and commons covered with furze or low brushwood, where it is almost always seen to alight upon the topmost spray; and the stone-chat (*S. rubicola*), which resides in Britain throughout the year, and is often found in moistish places. Of these the white-rump is the most esteemed as food, being compared by many to the ortolan. It is much sought after in Italy, that "land of song," where, by the strangest mal-association, a man no sooner hears a feathered warbler sing than he desires to shoot and eat it. Even in the southern parts of Britain it is much esteemed; and Pennant tells us, that as many as 1840 dozen have been taken in a single season at East Bourne, in Essex. In the south of Europe it is usually captured by means of a peculiar net, and the lure of a living owl; with us a noose of horse-hair placed between two upraised or inclined portions of turf, between which the bird attempts to pass in search of insects, is found sufficient. In regard to the stone-chat, Temminck mentions that, though stationary in Africa, in Europe they are birds of passage. It is singular in this case that they should remain throughout the year in Britain. The fact that they do so, however, is undoubted, as we have ourselves shot them on the Pentland Hills when the ground was covered with snow. Signor Savi mentions that they are stationary in Tuscany, although "per il tempo del caldo maggiore dell' estate, e dell autunno, molti abbandonano le pianure, e si retirano sù i monti per cercare luoghi più freschi."[3]

In the genus Sylvia of Wolf and Meyer (*Ficedula*, Bech.) the bill is merely a little narrower at the base than in the preceding. The generic title, however, has been variously applied of late, by different writers, to their restricted groups,—Mr Selby using it to designate our willow and wood wrens, while Cuvier makes it contain, among others, the four following British species, viz. the red-breast (*S. rubecula*), the blue-throat (*S. suecica*), the common red-start (*S. phœnicurus*), and the black red-start (*S. tithys*). Of these, the second and fourth can scarcely be regarded as otherwise than of accidental occurrence in England, and have never been seen in the northern quarters of the island. The red-breast is perhaps the most beloved of British birds, and is remarkable for its combination of familiarity and independence. When left to its "own sweet will," it enters houses freely in cold or snowy weather, will perch night after night on corniced book-case, or seek repose upon the golden scallop of a picture frame; but it hates all forwardness in others, and will not voluntarily come in contact with any hand, however beautiful. It hops delighted, singing as it goes with low and plaintive note, along the comfortable carpet, or darting up suddenly towards the window-frame, will utter a louder gush of angrier melody on seeing some orange-breasted brother, perched on leafless spray, still braving the increasing darkness. For a time, just before nightfall, he seems himself to suffer from some uneasy instinct, or probably desires, from habit, to secure his usual perch in old fantastic yew or thick screened holly; but, on second thoughts, he soon assumes some quiet corner, above the reach of curious children's hands. Not seldom when the evening fire burns brightest, he descends on muffled wing, his large and liquid eye dilated less with fear than quiet wonder, and after a brief survey, he re-ascends his place of safety. Although this bird remains about our doors throughout the summer, building near out-houses and in orchards, yet

> Some red-breasts love amid the deepest groves
> Retired to pass the summer days. Their song
> Among the birchen boughs, with sweetest fall
> Is warbled, pausing,—then resumed more sweet,
> More sad, that to an ear grown fanciful,
> The babes, the wood, the men, rise in review,
> And robin still repeats the tragic line.

We have a notion, that in Scotland the female red-breast is migratory. At least, in the vicinity of Edinburgh, we recognise her not throughout the long-enduring winter. All the individuals then about our gardens *sing* and *fight*, till, in the month of March, some strangers show themselves, but do not sing, and are immediately followed and

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[1] *Nat. Hist. and Classif. of Birds*, ii. 238. [2] *Fauna Boreali-Americana*, part ii. p. 20. [3] *Ornitologia Toscana*, i. 231.

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The red-start is a rarer species. It haunts retired well-wooded lanes, where the timber is in a better state than the stone dikes; for it highly approves of the latter when old, moss-covered, and full of holes. It is a bird of passage, and although greatly less familiar than the red-breast, we have seen it build beneath the cottage eaves. It is an active, restless bird, easily recognised by its snow-white forehead, black throat, ashy back, and fine reddish orange breast and rump, to say nothing of the constant vibratory motion of the tail.

The blue bird of America (*Sylvia sialis*) has the whole of the upper plumage of a fine blue, while the throat, neck, breast, and flanks, are bright orange brown. In general character and movement this bird resembles the European red-breast, and may be said to be as familiarly known in summer to the children of America as the robin is to ourselves. Wilson informs us that its society is much courted by the inhabitants of the country, and that few farmers neglect to provide for him a snug little summer-house, ready fitted, and rent free. He is migratory over the northern districts, but a few remain throughout the winter in some parts of the United States. A more recently described species, nearly allied to the preceding, was procured by Dr Richardson at Fort Franklin, and is named by Mr Swainson *Erythaca arctica*. Its colour is a fine ultra-marine blue above, beneath greenish blue, whitish on the lower part of the abdomen, and under tail-coverts. It seemed to be merely a summer visitant of the fur-countries, and no other knowledge of its haunts or habits has been yet obtained.

The genus Curruca, Bechstein, has the bill straight, slender throughout, a little compressed anteriorly, the upper mandible slightly curved towards the point. It contains that prince of European songsters, the nightingale (*C. luscinia*), a bird of shy and unobtrusive disposition, seldom seen in open places, but loving the protection of a close entangled undergrowth of brakes and bushes. Its powers of song are generally admitted to be unrivalled, although the effect is no doubt enhanced by the solemn stillness of the summer night, when every other voice has sunk to rest,—for then

> The wakeful bird
> Sings darkling, and in shadiest covert hid
> Tunes *her* nocturnal notes.

The words of the divine Milton are sacred; yet we know not that the female sings. It is a curious coincidence, however, that she should be asserted so to do by Pliny. Our British nightingales never venture farther north than Doncaster, although in Sweden and the northern parts of Germany they are less restricted in their summer movements. To this genus belong several other excellent British songsters, such as the rich-voiced black-cap (*C. atricapilla*), the greater petty-chaps (*C. hortensis*), and the white-throat or muggy (*C. cinerea*). These, as well as the following, are called abroad *fauvettes*.

A few species which affect damp underwood and reedy marshes, such as the grasshopper warbler (*S. locustella*), the sedge-warbler (*S. phragmitis*), and the reed-wren (*S. arundinacea*), constitute the genus Salicaria of Mr Selby. To the same little group, we doubt not, belongs the *beccamoschino* of the Tuscans (*Sylvia cisticola*, Temm.), remarkable as exhibiting the propensities of a tailor-bird. The nest is placed near, but not upon the ground, usually in a bush of lengthened herbage, the leaves and stalks which form the external covering being drawn together, while a flooring for the nest is made somewhat lower down, by curving the leaves across. The beauty of the structure consists in this, that the latter are not supported by their mutual interlacement, but are sewed together, sometimes by spiders' webs, sometimes by thread-like portions of various plants. The interior is chiefly composed of vegetable down. The nests constructed in April are much less finished than those of August, owing to the absence, in the earlier month, of several materials which greatly conduce towards their elegance and solidity.[1] Insessores.

Another limited genus, called Accentor, has the bill also slender, but rather more conical than the other Sylviæ, with the edges slightly bent inwards. The species are much more hardy than the preceding (all of which are birds of passage); and our only British representative, commonly called the hedge-sparrow (*A. modularis*), remains with us throughout the winter. It seems characteristic of the northern parts of Europe, being seldom seen in France except during winter; and the few that occur in Italy are known to breed among the mountains, only descending to the plains when the summer heat is over. With us what school-boy knows not its mossy, twig-entangled nest, and pure unspotted eggs of greenish blue? A larger and still hardier species is the alpine warbler (*A. alpinus*), of the accidental occurrence of which in the garden of King's College, Cambridge, an instance is recorded by Mr Selby. This bird is an inhabitant of the most mountainous regions of Europe, and particularly affects those districts which are of an abrupt and rocky character. It is common among the Alps of Switzerland, and may be usually seen in the environs of the convent of St Bernard. In summer it ascends to a great elevation, where it breeds beneath the ledges of the rocks, laying four or five eggs of a greenish-blue colour. As winter advances, and the snow begins to gather amid the desolate steeps, it descends towards the vales and middle regions of the mountains, where it subsists upon the seeds of alpine grasses, and of other plants. In summer it destroys grasshoppers, and various insects, and their larvæ.[2]

In the genus Regulus, Cuv., the bill is still slender, but conical, sharp pointed, and the sides, when viewed from above, are slightly concave. The species are much more active and arboreal than those last named. We may mention as an example our beautiful golden-crested wren (*R. auricapillus*, Selby; *Mot. regulus*, Linn.), the smallest of British birds. It inhabits woods and forests, and flits rapidly from tree to tree, examining the leaves and branches in search of insects. Its manners resemble those of the tit-mice, in company with which it often travels. Mr Selby has recorded, that after a severe gale from the north-east, *thousands* of these tiny creatures were seen to arrive upon the sea-shore and sand-banks of the Northumbrian coast,—many of them so fatigued as to be unable to rise again after alighting on the ground. In this genus Cuvier retains our willow or yellow wren, and lesser petty-chaps (*M. trochilus* and *hippolais*), which most other modern writers keep apart in their restricted genus Sylvia, bestowing other titles (*Erythaca*, *Phœnicura*, *Philomela*, &c.) on the genus which Cuvier has so called. These transpositions are the bane of Ornithology. Several true Reguli inhabit North America.

Our common (kitty) wren forms, with certain foreign species, the genus Troglodytes of Cuv. The bill is rather more slender than in Regulus, and slightly arched.

The generic name of Motacilla, of such extensive application in the older systems, is now restricted to the wag-tails, such as *M. alba* and *cinerea*, Linn. Our yellow

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[1] *Nuovo Giorn. de' Letterati*, t. vi. (where the nest is figured); and *Ornitologia Toscana*, t. i. p. 282.
[2] *Illustrations of British Ornithology*, vol. i. p. 247.

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species, which differs from the others in being a bird of passage, is moreover distinguished by an arched and lengthened hind claw, and forms the genus BUDYTES, Cuv., founded, perhaps, upon a character of no great importance. All the wag-tails are peculiar to the ancient continent.

The genus ANTHUS, Bechstein, so long united to the true larks, has the bill straight, slender, rather subulate towards the point, the base of the upper mandible carinated, the tip slightly bent, and emarginated. The hind claw is more or less produced. We have three British species, the rock or shore pipit (*A. aquaticus*), the tit-lark or meadow pipit (*A. pratensis*), and the tree pipit (*A. arboreus*). Richard's pipit (*A. Richardi*, Vieil.) may be included in our list of accidental visitants.

The great tribe of *Dentirostres* is terminated by Cuvier with certain groups which differ from all the preceding by the closer union of the outer and middle toes, which are joined together for a considerable space, after the manner of the syndactylous tribes.

Of these groups the first is composed chiefly of the *manakins* (Genus PIPRA, Linn.), in which the bill is short, compressed, higher than broad, notched, the nasal fossæ large, the nostrils concealed by feathers. The tail and legs are short. They may be subdivided as follows.

In the genus RUPICOLA of Brisson the species are of considerable size, and their heads are ornamented by a double crest of vertical feathers. The only species known are South American, and are distinguished by the name of rock manakins. *P. aurantia*, Vieil. (*Pipra rupicola*, Gm.), is of a brilliant orange colour, with peculiar frizzled feathers on the wings and tail. It is one of the most beautiful of birds, lives on fruits, scrapes in the ground like the Gallinæ, and constructs its nest among the deep caverns of the rocks. It is shy and mistrustful, and flies with great rapidity. The female, which is of a brown colour, lays two eggs of the size of those of a pigeon. The immature birds are also brown. This species inhabits the rocks by the rivers of Guiana. Not far from the banks of the river Oyapoc, to the windward of Cayenne, is a mountain which contains an immense cavern. There also, according to Waterton, the cock of the rock is plentiful. He is of a gloomy disposition, retiring during the day among the darkest rocks, and only coming out to feed a little before sunrise and at sunset. The South American Spaniards call him *Gallo del Rio Negro*, supposing that he is only met with in the vicinity of that far inland stream; but he is common in the interior of Demerara, amongst the huge rocks in the forests of Macoushia, and has been shot south of the line, in the captainship of Para. *R. Peruviana* is a nearly allied species, of somewhat larger size, but wanting the frizzled character of the wing and tail feathers. It inhabits Peru. The female is still unknown. Our author here places the beautiful green species from Java and Sumatra (*Calyptomena viridis* of Horsfield), which he thinks differs from the other Rupicolæ chiefly in the crest not being fan-shaped. (See Plate CCCXCI. fig. 7.) The true manakins (genus PIPRA, Cuv.) are of much smaller size. They likewise inhabit America, where they dwell in the deep and humid forests, feeding, it is said, both on fruits and insects. They are in general distinguished by the rich and varied colouring of their plumage. We have figured as an example a beautiful Brazilian species, the *Pipra pareola*. (See Plate CCCXCI. fig. 5.)

The terminal group of the *Dentirostres* is formed by the genus EURYLAIMUS, Horsfield, in which the bill is much stronger and broader than in any of the preceding, being in some of the species so greatly depressed and expanded at the base, as to exceed the breadth of the head. The upper overlaps the under mandible. These birds are peculiar to India and the great eastern islands, and now amount to five or six in number, which, however, offer such disparity in the structure of the bill, as to render subdivision unavoidable. This has been in part effected; the genus CYMBIRHYNCHUS, Vigors, containing *Eu. nasutus*, while the specific name of another (*Eu. corydon*), remarkable for the extraordinary expansion of the upper mandible, is used generically by M. Lesson, the species itself being termed *Temminckii*. (See Plate CCCXCI. fig. 8.) We know little of the manners of any of these birds. When actually ascertained, they may probably be found to offer a considerable disresemblance. They have hitherto been generally found in wild and desert places, by the banks of rivers, and are supposed to feed both on fruits and insects, —a frequent, if not a safe conclusion on the part of naturalists, regarding almost every unknown species which happens to be neither a goose nor an eagle.

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TRIBE 2D.—FISSIROSTRES.

This restricted tribe consists of the swallows, swifts, and goat-suckers, and is characterized by the bill being short, broad, depressed, slightly curved, without any tooth, and so deeply cleft as to give peculiar wideness to the gape,—a structure of great use to birds which prey so exclusively on insects taken on the wing. Their insectivorous regimen induces migratorial habits, and all the species leave ourselves and other northern nations so soon as the sear and yellow leaves of autumn betoken the approach of frost, and the consequent decrease or extirpation of insect life. Like the raptorial order, or birds of prey properly so called, the fissirostral tribe is capable of a binary division into diurnal and nocturnal species.

Swallows, in general (HIRUNDO, Linn.), are remarkable for their close-set, usually glossy plumage, the great length of their wings, their swift, powerful, easy, and long-continued flight. They occur in almost every region of the globe. In the restricted genus HIRUNDO, Cuv., the toes are disposed as in the majority of birds, that is, three anterior and one posterior. In some of the species the legs and feet are clothed with feathers, the hind claw is slightly disposed to turn forwards, the tail is forked, and of medium size. Such is our martin or window-swallow (*H. urbica*) which forms so cheerful a feature in many of our villages and country dwellings, building beneath the eaves of houses, or the upper angles of windows. It is glossy bluish-black above, the rump and all the lower regions white. In others the legs and feet are naked, the tail forked, and of great length. Such is our chimney-swallow (*H. rustica*), which usually builds in out-houses, and leaves the top of its nest uncovered. Its upper parts, and the higher portion of the breast, are black; the forehead and throat deep orange-brown, the lower portions of the body white. This species usually appears a few days earlier in April than the preceding. Although the migratory movements of both these birds may be still regarded as mysterious, there is now no doubt of the fact that they do migrate. It appears from the observations of M. Natterer, that they moult in February, that is, during their absence from this, the land of their nativity,—a fact which would of itself suffice to overthrow the idea of their long-protracted winter sleep. It is also in respect to other purposes as usual well ordained, for if the heavy moult which befalls so many species during spring or autumn, were equally to affect these long-winged birds, their flight from foreign lands, or journey thither, might be procrastinated, or prevented altogether. Swallows are probably the most purely and exclusively insectivorous of all birds, and even if they could themselves withstand our winter's cold. they would soon perish miserably from want of food.

This extreme sensibility of course renders it difficult to keep swallows caged, or otherwise confined, throughout the winter season. Yet several instances are known

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of their surviving that inclement period. The following is given by Mr Bewick, on the authority of the late Sir John Trevelyan. The experiments were made by a Mr Pearson. "Five or six of these birds were taken about the latter end of August 1784, in a bat-fowling net, at night; they were put separately into small cages, and fed with nightingale's food. In about a week or ten days they took the food of themselves: they were then put altogether into a deep cage, four feet long, with gravel at the bottom; a broad shallow pan with water was placed in it, in which they sometimes washed themselves, and seemed much strengthened by it. One day Mr Pearson observed that they went into the water with unusual eagerness, hurrying in and out again repeatedly with such swiftness as if they had been suddenly seized with a frenzy. Being anxious to see the result, he left them to themselves about half an hour, and on going to the cage again found them all huddled together in a corner apparently dead; the cage was then placed at a proper distance from the fire, when two of them only recovered, and were as healthy as before—the rest died; the two remaining ones were allowed to wash themselves occasionally for a short time only; but their feet soon after became swelled and inflamed, which was attributed to their perching, and they died about Christmas. Thus the first year's experiments were in some measure lost. Not discouraged by the failure of this, Mr Pearson determined to make a second trial the succeeding year, from a strong desire of being convinced of the truth respecting their going into a state of torpidity. Accordingly, the next season having taken some more birds, he put them into the cage, and in every respect pursued the same methods as with the last; but to guard their feet from the bad effects of the damp and cold, he covered the perches with flannel, and had the pleasure to observe that the birds throve extremely well. They sang their song through the winter, and soon after Christmas began to moult, which they got through without any difficulty, and lived three or four years, regularly moulting every year at the usual time. On the renewal of their feathers, it appeared that their tails were forked exactly the same as in those birds which return hither in the spring, and in every respect their appearance was the same. These birds were exhibited to the Society for promoting Natural History, on the 14th February 1786, at the time when they were in a deep moult, during a severe frost, when the snow was on the ground. They died at last in the summer, from neglect during a long illness which Mr Pearson had, who concludes this interesting account with the following words: 'January 20, 1797.—I have now in my house, No. 21 Great Newport Street, Long-Acre, four swallows in moult, in as perfect health as any birds ever appeared to be in when moulting.'"[1] Our only other species is the sand-swallow, or bank-martin (*H. riparia*), of smaller size and browner colour. It is the earliest of the genus; but being more locally distributed, its arrival in many districts is not so speedily observed.

Among the foreign species, one of the most remarkable is *H. esculenta*, a small brown swallow, from the Indian Archipelago. Its nest, formed chiefly of a peculiar kind of sea-weed, is very mucilaginous when cooked; and its restoratory virtues are held in such high esteem, that it has become with eastern nations, especially the Chinese, a most important article of commerce. The best kinds (such as are white and transparent, and of a uniform and delicate texture) sell at from a thousand to fifteen hundred dollars the peckul (not more than twenty-five pounds). The Dutch alone were in use to export from Batavia about a thousand peckuls every year; but of these, a great proportion was brought from the islands of Cochin-China, and others to the eastward. However, these nests are nowhere more abundant than about Croee, near the south end of Sumatra. They weigh each about half an ounce, and resemble a small saucer in shape, with one side flattened, by which they adhere to the rocky walls of caverns. Their texture resembles that of isinglass, or fine gum-dragon. When about to be used they are soaked, then pulled to pieces; and after being mixed with ginseng, are put into the body of a fowl, which is stewed all night with a sufficient quantity of water. When dissolved in broth they are said to give it a delicious flavour.[2] Naturalists are not agreed as to the exact mode of formation of these nests. Some suppose them the result of a glandular secretion. Alexander Wilson says, that the aculeated swallow (*H. pelasgia*) of America fastens together the twigs which compose its nest by means of a strongly adhesive gummy matter, secreted by two glands placed on each side of the hinder portion of the head.[3]

The swifts belong to the genus Cypselus of Illiger, distinguished by the extreme shortness of the legs, and the peculiar character of all the four toes being directed forwards. The middle and outer toes have only three articulations. Of all the feathered race, these are perhaps the most vigorous and unwearied flyers. Even in the skeleton, the shortness of the humerus, the breadth of its apophyses, the oval form of the fourchette, and the sternum unnotched below, indicate a structure admirably suited to sustain aërial motion; and when to these we add the enormously lengthened primary feathers of the wings, we have a flying machine of the most powerful kind. We doubt not that during every summer evening in which these sable creatures pursue their gladsome gambols through the unresisting air, they travel many hundred miles. It is easy to observe, that they are often on the wing incessantly for hours together, careering in fine weather in vast and intersecting circles, screaming after each other in no melodious strains, and flying at such a maddening rate as if flight were the only faculty worthy of exercise in earth or heaven; and we are sure that the same genius for arithmetic which enables a school-boy to ascertain how many grains of barley would surround the world, might, if applied to every minute's flight of this surprising bird for one "purpureal eve," elicit a result in distance which would astonish even a railway engineer. Our common swift is the *Cypselus murarius* of Temm. (*Hirundo apus*, Linn.). These birds, as well as swallows, seem in many instances to return to the same spot for a series of years. Dr Jenner took two claws from the foot of twelve swifts. Several were re-taken in the course of one or two seasons; and at the expiration of seven years, one was brought in by a cat. A larger species (*C. alpinus*, Temm.), frequent among the Alps of Switzerland and the Tyrol, and well known at Gibraltar, has occurred occasionally in Ireland. There are a great many foreign species, both of swifts and swallows.

In the genus Caprimulgus, Linn., the gape is still wider, and the beak is bristled at the base with stiffish hairs. The wings are very long, the legs short, the tarsi usually feathered, the toes united at the base by a membrane, slightly connecting even the hinder toe, which is somewhat versatile; the middle toe is often toothed on its inner edge (see Plate CCCXCI. fig. 6 *a*); and the outer one, by a conformation of rare occurrence amongst birds, has only four articulations.

The Caprimulgi or goat-suckers (an absurd and fabu-

[1] Bewick's *British Birds*, i. 254.

[2] See Shaw's *General Zoology*, vol. x. p. 111; and Sir G. Staunton's *Embassy to China*, vol. i. p. 288, and vol. ii. p. 5. This species seems described under the name of *H. fuciphaga*, in *Act. Holm.* t. xxxiii. p. 151.

[3] *American Ornithology*, vol. ii. p. 24.

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lous term, which, however, serves the best purpose of a name, in being generally understood to relate to the species in question) are solitary birds, which feed voraciously on insects, and fly about during the evening twilight, encroaching in mid-summer on the clear and stilly hours of night. Our only British species (*C. Europæus*) is a bird of passage; and in its beautifully brindled plumage of ashy-gray, brown, and black, with here and there a patch of white, presents a characteristic example of the genus. It frequents commons, heaths, and uncultivated tracts, especially where interspersed with brushwood. When on the wing, it utters occasionally a sharp hawk-like cry; but Cuvier surely errs when he asserts that "l'air qui s'engouffre, quand ils volent, dans leur large bec, y produit un bourdonnement particulier." If he alludes to the peculiar purring and prolonged sound which some compare to that of a spinning-wheel, there is no doubt of its being produced when the bird is at rest, on the top of a wall, or among a heap of stones. When perched upon a branch or paling, its position is peculiar. It rests horizontally in the same direction as that by which it is supported, instead of across or at right angles. Its flight, when pursuing moths and beetles, is very easy and graceful. The species of this genus are widely distributed. Three occur in North America; several in the southern parts of the new world; in New Holland they are well known; Africa produces some remarkable kinds; and those of Java and the East have been described by recent naturalists. Out of these, however, several subordinate genera have been created. The strong-billed species, which want the membrane between the toes, and the dentation of the middle claw, form the genus Podargus. They are natives of New Holland and the eastern islands. (See Plate CCCXCI. fig. 6.) The great species from Guiana, which has the sides of the upper mandible dilated into a blunt tooth, constitutes the genus Nyctibius of Vieillot. A very peculiar species (*Guacharo de caripe*), which feeds on fruits, and dwells gregariously in caverns, where the young are much sought after on account of their delicious fat, forms the genus Steatornis of Humboldt.[1] It is the only frugivorous night-flying bird with which we are acquainted.

Although the general title of goat-sucker is so familiar to our ears, we confess we were never aware of how it had originated,—deeming it some accidental and unmeaning application,—till we had read the following passage in Mr Waterton's work. "When the moon shines bright, you may have a fair opportunity of examining the goat-sucker. You will see it close by the cows, goats, and sheep, jumping up every now and then under their bellies. Approach a little nearer,—he is not shy,—'he fears no danger, for he knows no sin.' See how the nocturnal flies are tormenting the herd, and with what dexterity he springs up and catches them, as fast as they alight on the belly, legs, and udder of the animals. Observe how quietly they stand, and how sensible they seem of his good offices; for they neither strike at him, nor hit him with their tail, nor tread on him, nor try to drive him away as an uncivil intruder. Were you to dissect him, and inspect his stomach, you would find no milk there. It is full of the flies which have been annoying the herd."[2] Many an hour, during the long still summer evenings, have we watched the flight of our only British species, while it hawked for moths along the fringed margins of the rocky woods, or glanced more openly across the dewy meadows which bank the crystal basin of the "beautiful Winander,"—but we never saw it hovering around or near to any kind of cattle. We doubt not, however, that the same habit, as noted by Mr Waterton, must have been observed in Europe, and has, through misconception, originated the vernacular name.

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Tribe 3d.—Conirostres.

In this tribe are comprehended a considerable variety of genera, exhibiting not a little disparity in size, structure, and habits, but agreeing in their bills being comparatively strong, more or less conical, and without notch. Several of the species, such as crows and magpies, are omnivorous; but, generally speaking, when compared with either of the two preceding tribes, the diet of the Conirostres may be termed granivorous.

The first little group is constituted by the larks, genus Alauda, Linn., of which the greater number have the bill straight, moderately thick, and pointed. (See Plate CCCXCII. fig. 1.) Though their flight is occasionally lofty and sustained, and the sky-lark (*A. arvensis*) obtains its name

> From warbling high
> His trembling thrilling extacy,
> As, lessening from the dazzled sight,
> He melts in air and liquid light,—

yet they haunt, and build their humble nests, habitually in fields of grain or grassy meadows. Even the wood-lark (*A. arborea*), although it perches and sometimes sings on trees, rears its young upon the ground. The shore-lark of Pennant (*A. alpestris*, Gmel.) is common to the northern parts of Europe, Asia, and America.

In the genus Parus, Linn., the bill is small, short, conical, straight, beset at the base with hairs, and the nostrils concealed by feathers. The species commonly called *titmice* are lively, active little birds, usually observed flying with eagerness from tree to tree in search of insects, scaling the branches in all directions, and seemingly quite regardless whether their heads or their heels are uppermost. Their nests are usually placed under cover, either in the crevice of a wall or the hollow of an old tree, and the number of eggs which they lay exceeds that of most Passeres. They eat grain and seeds, as well as insects. The species are distributed over the whole world, with the exception of New Holland, South America, and the islands of the South Pacific Ocean. Although of rather gay and beautiful plumage, they are more numerous in temperate and northern countries than between the tropics. We have seven species in Britain, of which the bearded titmouse (*P. biarmicus*) is scarce, and partially distributed, and the crested species (*P. cristatus*) so extremely rare as to be regarded as accidental. From the small size, rapid movements, and usually arboreous habits of all these birds, their doings can scarcely be observed with advantage during the umbrageous summer. But when the woods have either lost their leafy glory, or the dry red foliage hangs unresistant of the slightest breath, then are these vivacious creatures seen to congregate in little flocks, sometimes several species joining together, and cheering each other on with frequent shrilly cries. In their foraging excursions they likewise visit our gardens, shrubberies, and cottage doors, plundering the farm-yards, eating potatoes with the pigs and poultry, and greedily searching out an old marrow-bone, or (if in Scotland) a sheep's head of the preceding Sunday. The suspended nests of some of the foreign species are extremely elegant, and even that of our own long-tailed species is an object of great interest and beauty. Mr Selby describes it as usually fixed in one of the smaller forks of a tree branch, but occasionally amid the closer screen of a fir, or the centre of a thick bush of woodbine or thorn. It is of a longish oval form, composed of different

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[1] *Acad. des Sciences*, Mars 1817, *Nouv. Bull.* 1817, p. 51.

[2] *Wanderings in South America*, p. 143.

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lichens and wool firmly and curiously interwoven, and lined with a profusion of feathers. A small hole is left on two opposite sides of the nest, not only for ingress and egress, but also to prevent the bird during incubation from being incommoded by its long tail, which then projects through one of the orifices. The eggs are white, with fine reddish-brown specks upon the larger end, and usually amount to ten or twelve.[1] The *Parus pendulinus*, a species of the southern parts of Europe, constructs a purse-shaped dwelling, suspended from the flexible branches of aquatic plants, or interlaced among the waving reeds. This hang-nest tit-mouse is often seen among the marshes of Bologna, where the peasantry seem to regard it with the same kindly affection as we do our red-breast.

The genus EMBERIZA, Linn., is distinctly characterized by its rather short, straight, conical bill, and the curved form of the gape, produced by a narrowing of the sides of the upper mandible, and a corresponding enlargement of the under one. Instead of being as usual concave within, the upper mandible has a hard, rounded knob in the inside, or what is called a tuberculous palate. The species commonly known by the name of buntings feed chiefly on seeds and grain. The ortolan (*E. hortulana*), a native of the central and southern provinces of Europe, has been occasionally killed in England. It is much esteemed in Italy and elsewhere as an article of food. It is frequently lean when first netted; but if left undisturbed and well fed, it will not only fatten rapidly, but even in many instances die of repletion. The snow-bunting, and a few other kinds, distinguished chiefly by the elongation of the hind claw, form the genus *Plectrophanes* of Meyer, now called lark-buntings by our English writers.

The great genus FRINGILLA of Linn. has the bill also conical, and more or less thickened at the base; but the commissure is not angularly curved, as in the preceding group. Numerous subdivisions have been made of this genus in modern times. Of these the following may be taken as examples.

In PLOCEUS, Cuv., the bill is rather square at the base, but sharp-pointed; the upper mandible somewhat dilated. The species are known by the name of weavers, on account of the art with which they join together the materials of their nests. Several species are gregarious, even during the breeding season, hanging their nests close together in the same tree; and as each on building a new nest forms it in close connection with the old, the final result is, that an apparently solid mass is at length collected, consisting of numerous apartments, each tenanted by a pair of birds, but having the external appearance of one gigantic dwelling. Cuvier here places the species known in the older systems as the Philippine gross-beak, *Loxia Philippina*, Linn. This bird is known in India by the name of baya, and may be rendered so tame as not only to perch upon the hand, but to fetch and carry at command. It builds a very curious nest, in the shape of a long cylinder, swelling out into a globose form in the middle, and composed of the fine fibres of leaves and grass, fastened by the end to a lofty branch, generally of the Palmyra or Indian fig-tree. The eggs are said to resemble pearls, with the white part transparent even when boiled, and are accounted delicious eating. This species is alleged to feed on fire-flies. Another remarkable Ploceus is the sociable gross-beak, or republican, *Loxia socia*, Latham. It is an inhabitant of the interior of the Cape country, and is thus described in Paterson's *Travels:* "Few species of birds live together in such large societies, or have such an extraordinary mode of nidification, as these; they build their nests on the mimosa trees, which grow to a very large size, and appear to be well calculated for the purpose, as the smoothness of their trunks prevents the birds from being attacked by monkeys, and other noxious animals. The method in which their nests are made is very curious. On one tree there could not be less than from eight hundred to a thousand under one general roof. I call it a roof, because it resembles that of a thatched house, and projects over the entrance of the nest below in a very singular manner. The industry of these birds seems almost equal to that of the bee. Throughout the day they appear to be busily employed in carrying a fine species of grass, which is the principal material they employ for the purpose of erecting this extraordinary work, as well as for additions and repairs. Though my short stay in the country was not sufficient to satisfy me by ocular proof that they added to their nest as they annually increased in numbers; still, from the many trees which I have seen borne down by the weight, and others which I have observed with their boughs completely covered over, it would appear that this is really the case. When the tree which is the support of this aërial city is obliged to give way to the increase of weight, it is obvious that they are no longer protected, and are under the necessity of rebuilding in other trees. One of these deserted nests I had the curiosity to break down, to inform myself of the internal structure of it, and found it equally ingenious with that of the external. There are many entrances, each of which forms a regular street, with nests on both sides, at about two inches distance from each other. The grass with which they build is called the Boshman's grass, and I believe the seed of it to be their principal food, though, on examining their nests, I found the wings and legs of different insects. From every appearance, the nest which I dissected had been inhabited for many years, and some parts of it were more complete than others. This, therefore, I conceive to amount nearly to a proof that the animals added to it at different times, as they found necessary, from the increase of the family, or rather of the nation or community."[2]

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The genus PYRGITA, Cuv., contains the sparrows properly so called, of which the common house species (*P. domestica*) affords a familiar example. This bird is characteristic of the temperate and more northern parts of Europe, and is scarcely known in Italy to the south of Piedmont, being replaced by a closely-allied species, *P. cisalpina*, which is the *Passer volgare* of Italian authors. Although M. Temminck thinks that the manners of the latter are less domestic than those of our more northern kind, and that its love of fields and country places ally it rather to the *P. montana*, we doubt not that all who have lived in Italy will be of a contrary opinion,—in agreement with the following beautiful passage by Professor Savi, which we shall not injure by translating. "Sembra che quest' uccello non possa vivere se non con l'uomo. Eccetuate quelle regioni alpestri ove regnano perpetuamente i ghiacci, in qualunque altro luogo in cui l'uomo si è stabilito, la Passera l'ha accompagnato; e indifferente alla prospera, o contraria fortuna, essa ha posta dimora nella dimora di lui. In riva delli stagni, in mezzo alla quiete de' boschi delle Maremme, sulla povera ed umile capanna d'un piscatore o d'un pecorajo, han domicilio le passere, le quali trovano il loro cibo nella sementa di grano del piccolo campo, ne' frutti dell' orticello, nello scarso becchime gettato alle galline o a' piccioni. E nel modo stesso voi le vedete nel contro delle più grandi e clamorose città, porre il nido fra gli ornati d'una grandiosa cattedrale, o sù i tetti d'un giardin di delizia, e cercare le granella o miche di pane in mezzo alle piazze più popolate. Ma se l'uomo cessa d'abitare

[1] *British Ornithology*, i. 241.

[2] *General Zoology*, vol. ix. p. 303.

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quella capanna, o quella città, la passera anche essa l'abbandona. Chi, girando nelle maremme, passa per antiche e disabitate abbazìe, per fortilizi, o ville in rovini, vedra dalle finestre più elevate di quelle, fuggire de' piccioni insalvatichiti, udirà gridar la civetta che abita fra li spacchi de' muri vestiti d'ellera e parietaria, vedrà la ballerina continuare a fabbricarvi il nido, ma in vano egli la cercherà il volatile parasito dell' Europeo, quella specie d'uccello che prima per il numero ogni altro ne superava in quel luogo. Così nel modo stesso che una figura geometrica vista sulla sabbia fu giudicata dal naufraga Filosofo per un segno certo della vicinanza dell'uomo, per un tal segno ancora può ritenersi la presenza delle passere."[1] In regard to our own species, Savi observes, "non mi è noto se ne stiano anche in Lombardia, ma so di certo che alcuno giammai ne è stato visto in Toscana." According to Temminck, the boundary of the latter species is the great chain of the Alps, on the southern slopes of which it disappears in favour of the cisalpine kind. But it is our common British sparrow which occurs about Trieste, and through the north of Dalmatia, although separated from the region of *P. cisalpina* only by the waters of the Adriatic. "I costumi," adds the Italian author, "di queste due specie sono precisamente gli stessi. Io ho accuratamente ed in varj tempi osservate le abitudini della *F. domestica*, tanto in Svizzera che nel settentrione della Francia, e posso assicurare che le stesse sono di quelle della nostra specie Italiana."[2]

In the restricted genus FRINGILLA, Cuv., the bill is rather less arched than in the sparrows, and a little stronger and more lengthened than among the linnets. Cuvier includes in it the chaffinch (*F. cœlebs*), the mountain-finch or brambling (*F. montifringilla*), and the snow-finch (*F. nivalis*). The latter is scarcely ever found except in the near vicinity of ice and snow, and may be regarded (in common with *Accenter alpinus*) as the most mountainous of all the smaller birds of Europe. Yet though wild and solitary in our estimation, from associating it with the desolate scenery of the rock-surrounded glaciers, it is beautiful to see how, in the neighbourhood of the lonely shepherd chalets of the Alps, it loves to humanise its feelings; and how, among the few sad dwellings of the Mount Cenis, and other lofty passes, it perches on the roofs of houses, hops about the beaten foot-paths, and builds among dismantled yet protecting walls. In winter it seeks subalpine regions, or the snow-covered valleys of Piedmont, but scarcely ever migrates to the lowest plains. It is unknown in Tuscany.

In the genus CARDUELIS, Cuv., the bill is more exactly conic, without bulging in any portion, and is rather lengthened. We may name as an example, our beautiful, lively, and intelligent goldfinch (*C. elegans*, Steph.,—*F. carduelis*, Linn.), a bird widely distributed over Europe, and extending from the sultry shores of the Mediterranean to the plains of Siberia. It occurs in Holland only as a bird of passage. The siskin (*F. spinus*) is by some considered as a Carduelis, while others place it with the group which follows, viz. genus LINARIA, Bechstein, in which the bill is equally conical, but not so long. Here we place our gray linnets and red-poles, among which the more or less decided crimson tinting of the breast and forehead, according to age and season, has occasioned some confusion. Our common or gray linnet (*F. cannabina*, Linn.,—*F. linota*, Gmel.) is, in the perfect nuptial plumage, synonymous with the rose-linnet and greater red-pole. Our lesser red-pole is the *F. linaria* of Linn.; and the only other British species is the twyte or mountain-linnet, *F. montium*, Gmel., formerly regarded as a bird of passage, but now known to breed in the northern counties of Scotland, if not elsewhere in Britain. We have caught the young ones, half-fledged, among the Grampian Mountains. The amount of foreign species is considerable. Of these, one of the most remarkable for its musical powers is the well-known canary (*F. canaria*, Linn.), a native of the Cape de Verd and other islands, where its natural plumage is green. It breeds readily in confinement with the linnet, goldfinch, siskin, and other species.

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The genus VIDUA, Cuv., contains some remarkable species, with the bill more inflated at the base than the preceding, but chiefly characterized by the extreme elongation of the caudal plumage of the males. They inhabit India and Africa, and were placed by Linnæus among the buntings.

The genus COCCOTHRAUSTES, Cuv., containing the gross-beaks, has the bill very conical, but of extreme thickness at the base, and rapidly tapering to the point. The culmen is rounded, the commissure slightly arched. The species occur in America, as well as in the ancient continents. The haw-finch (*C. vulgaris*,—*Loxia coccothraustes*, Linn.) visits the southern parts of Britain occasionally during winter, and is even said to have been found breeding in Windsor Forest. It feeds upon the larger kinds of seeds and berries, which it is enabled to bruise and break at pleasure, by means of the great strength of its bill. The evening gross-beak (*C. vespertina*, Cooper) is a beautiful American species, with the frontal feathers and a line above the eye yellow, the crown, wings, and tail black, the secondaries and inner wing-coverts white, the bill pale yellow. This newly-discovered bird inhabits the solitudes of the north-western interior, being met with from the extremity of the Michigan territory to the Rocky Mountains, and it is not uncommon towards the upper end of Lake Superior and the borders of the Athabasca Lake. To the east of these regions it appears to be only a transient visitor during spring and autumn. Our homely and heavy-headed green linnet (*C. chloris*, Fleming), of which the mature male is a rich and beautifully plumaged bird, belongs to our present genus. It is probable that the *Fringilla incerta* of Risso, figured by M. Roux (in his *Ornithologie Provençale*), is nearly allied. It is one of the rarest of the European birds, appearing occasionally during the autumn in Provence, and likewise occurring in the vicinity of Palermo.

In the genus PITYLUS, Cuv., are contained a few species (almost all, we believe, from South America), in which the bill, though thick, as in the preceding, is rather compressed, arched above, and has sometimes a projecting angle in the middle of the margin of the upper mandible. Such are the *Loxia grossa*, *Portoricensis*, &c.

In the genus PYRRHULA, in which the bill is shorter and greatly bulged, we have the bullfinches, of which our British species, *P. vulgaris*, Temm.,—*L. pyrrhula*, Linn., is a well-known example. It is very generally distributed throughout our wooded districts, but is nowhere very abundant, and may be called scarce in several quarters of the island.

In the genus LOXIA of Brisson, as now restricted, the bill is compressed, and the two mandibles so curved and deflected, that when closed they cross each other. This extraordinary structure is supposed to afford the species great facility in stripping the scales from the well-protected seeds of the various kinds of pine-trees. The crossbills are few in number, and occur both in Europe and America. Their habits as breeding birds are little known, but the period of incubation must be very early, as *L. curvirostra* sometimes visits this country in small flocks as early as June. Temminck says, somewhat vaguely, in regard to the parrot-billed species (*L. pytiopsittacus*), that it "niche en hiver dans nos climats, sur les branches de sapin; en Livonie l'espèce niche dès les mois de Mais."

[1] *Ornitologia Toscana*, t. ii. p. 100.

[2] *Ibid.* p. 106.

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Their chief haunts are probably within the arctic circle. In America they are believed to breed about Hudson's Bay, being seen in the United States only from September to April. It thus appears, at all events, that they do not there breed during the winter season.

The great pine gross-beak (*Loxia enucleator*, Linn., by some regarded as a bullfinch) may be here named as belonging to the genus Corythus of Cuvier. It is a northern species, occurring in the colder regions both of Europe and America. Although Pennant mentions having met with it in the woods of Invercauld in the month of August, we are not aware of its having ever since been seen in Scotland.

In the genus Colius, Gmelin, the bill is short, thick, conical, somewhat compressed, both mandibles arched, and of nearly equal length. The feathers of the tail are long and graduated, and the plumage, for the most part fine and silky, is usually ash-coloured. The hind toe can assume a forward direction, almost as in the swifts. (See Plate CCCXCII. fig. 3.) The species are found in India and Africa. Prior to the time of Vaillant, we knew little of their habits. They are now known to be gregarious, endowed with but feeble powers of flight, but almost as skilful as parakeets in climbing. They are not at all addicted to insect food; but their love of fruits, and the tender buds of trees, makes them very injurious wherever land is under horticultural care. They not only dwell together in society, but build their nests in little groups upon the same thorny bush. They are moreover distinguished by a singular custom of sleeping close together, suspended head downwards from the branches. The species here represented (Plate CCCXCII. fig. 2) is *C. leuconotus*, Lath. (*C. erythropus*, Gmel.), supposed to be identical with *C. capensis*, Linn.

The genus Buphaga of Brisson has the bill square at the base, and rather gibbous towards the point, which is abbreviated. The species, only two in number, are insectivorous, and have derived the name of beef-eaters from their habit of picking larvæ from the hides of the larger kinds of cattle, thus freeing them from noxious parasites. The South African species (*B. Africana*, Linn.) was observed by Vaillant in the country of the Namuquas in small flocks. He found it shy, and difficult to be approached. The other species referred to this genus is the *B. erythrorhyncha* of Temm., common in the north-eastern countries of Africa, where it follows caravans for the sake of picking insects from the woolly backs of camels, and other beasts of burden. It is singular, that although hitherto unknown in Southern Africa, it should have been received from Madagascar.

In the genus Cassicus of Cuv. the bill is much more exactly conical, thick at the base, extremely sharp pointed, the commissure forming an angulated line as in the starlings. These are American birds of gregarious habits, which feed both on fruits and insects, and frequently exhibit such surprising skill and ingenuity in the structure of their nests, that an old lady once gravely asked an American Ornithologist whether he did not think they might be taught to darn stockings. In the genus Cassicus properly so called, the base of the bill ascends upon the forehead, so as to encroach broadly upon the frontlet feathers. Here are contained the largest species. The one we have figured (*C. cristatus*, Plate CCCXCII. fig. 5) is from Cayenne. In the genus Icterus the bill is arched, and does not extend upon the forehead except by a sharp notch.[1] With the Icteri Cuvier combines the purple grakle, or crow blackbird of America (*Quiscalus versicolor* of Vieillot), between which and the fish-hawk a singular understanding seems to be kept up. The nest of the latter is of large dimensions, often from three to four feet in breadth, and from four to five feet high, composed externally of large sticks or faggots, among the interstices of which several pair of crow blackbirds will construct their nests, while the hawk sits hatching over all. These birds are very injurious to the crops of Indian corn, and sometimes collect in prodigious flocks, descending on the fields like a blackening tempest. They occupy a great extent of territory, being widely spread from Hudson's Bay to within the tropics. They are migratory in the colder districts, and on their first arrival feed on insects as well as seeds.[2] According to Dr Richardson, their first appearance on the plains of the Saskatchewan is very striking. They arrive from their southern winter quarters in the beginning of May, the males and females in separate flocks of from twenty to a hundred, which perch in crowds upon the leafless branches of the trees, their plumage shining with metallic splendour.

The genus Xanthornus (*les carouges*) scarcely differs from the preceding, except that the bill is straight. Here Cuvier places many of the American orioles, such as the red-shouldered species (*O. phœniceus*, Linn.). These "red-winged starlings," as Wilson calls them, are generally migratory in the states north of Maryland, but are found during winter in immense flocks along the lower parts of Virginia, both Carolinas, Georgia, and Louisiana, particularly near the sea-coast, and in the vicinity of large fields of rice and corn. "In the months of January and February, while passing through the former of these countries, I was frequently entertained with the aërial evolutions of these great bodies of starlings. Sometimes they appeared driving about like an enormous black cloud carried before the wind, varying its shape every moment; sometimes suddenly rising from the fields around me with a noise like thunder; while the glittering of innumerable wings of the brightest vermilion amid the black cloud they formed, produced on these occasions a very striking and splendid effect. Then descending like a torrent, and covering the branches of some detached grove, or clump of trees, the whole congregated multitude commenced one general concert or chorus, that I have plainly distinguished at the distance of more than two miles; and when listened to at the intermediate space of about a quarter of a mile, with a slight breeze of wind to swell and soften the flow of its cadences, was to me grand, and even sublime. The whole season of winter, that with most birds is past struggling to sustain life in silent melancholy, is with the red-wings one continued carnival. The profuse gleanings of the old rice, corn, and buck-wheat fields, supply them with abundant food, at once ready and nutritious; and the intermediate time is spent either in aërial manœuvres, or in grand vocal performances, as if solicitous to supply the absence of all the tuneful summer tribes, and to cheer the dejected face of nature with their whole combined powers of harmony."[3]

In this genus some have also placed the noted cow-pen bird of Catesby (*Icterus pecoris*, Bon.; *Emb. pecoris*, Wilson), of which the most remarkable feature consists in its

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[1] For a detailed classification of the Icteri of Brisson, see Mr Vigors's "Sketches in Ornithology," *Zoological Journal*, No. vi. p. 182.

[2] Great confusion exists in the nomenclature of these birds, and of their congeners the troupials, hang-nest orioles, and other American species, chiefly in consequence of the transposition of names. Almost every author has composed his groups of different materials, and of course has applied his designations differently. The genus *Quiscalus* of Vieillot contains four well-ascertained species, *Q. major*, *versicolor*, *ferrugineus*, and *baritus*.

[3] *American Ornithology*, vol. i. p. 193.

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depositing, like our European cuckoo, its eggs in the nests of other birds. The circumstances by which Wilson first became acquainted with this peculiar habit are as follows. He had in numerous instances found in the nests of three or four particular species, one egg much larger and differently marked from those beside it. He at length detected the female of this cow-bunting, as he calls it, in the act, that is, sitting in the nest of the red-eyed fly-catcher, (her eyes might well be red, if she had ever fondly hoped for a legitimate posterity), which happens to be a very small one, and singularly constructed. Suspecting her purpose (and truly her position was more than suspicious), he cautiously withdrew without disturbing her, and had the satisfaction to find on his return, that she had left an egg exactly like that just alluded to. He afterwards, in many instances, found the young cow-bunting in the nest of these and of other birds, and also observed the latter followed by a foster child calling most clamorously for food. The cow-bird is gregarious and migratory, entering the middle and northern states about the end of March or beginning of April, and passing northwards as the season becomes milder. It arrives in the fur-countries in May, ranges to the sixtieth parallel, departs in September, and collects in large flocks in Pennsylvania during the following months, after which it retires to winter in the more southern states and Mexico. Its food consists of grain, grass, and worms, particularly certain intestinal ones, which it finds in the dung of cattle. The cow-bunting never pairs, and a state of general concubinage seems to prevail amongst them. Bred up as foundlings in the nests of other birds, and fed by foster parents,—owing their existence and preservation to a system of cunning deception, and commencing their career by the destruction of the natural inmates of that mossy dwelling in which they passed their own delusive infancy,—what hopes can here be cherished of the hallowed growth of home affections? When the female is disposed to lay, she appears restless and dejected, and separates herself from the unregarding males, who care not for posterity. Stealing through the woods and thickets, she pries insidiously into every bush and branch for a nest that suits her fancy, and into it she darts in absence of the owner, and in a few minutes is seen to rise upon the wing, relieved from all maternal care. If the egg be deposited alone, that is, in a previously empty nest, it is almost uniformly forsaken; but if the nursing mother has any of her own she immediately begins to sit. The red-eyed fly-catcher (*Vireo olivaceus*) proves a most assiduous foster-parent. In the beautiful basket-like nest of one of these birds, Mr Nuttall found an egg of each species, and the female fly-catcher already sitting. He removed her own egg, and left that of the stranger. She soon returned, and, as if sensible of what had happened, gazed steadfastly, shifted the egg, sat on it for a time, moved off, renewed her observation, and at length settled down upon her nest. Two or three days after, however, she was found to have left the premises. Yet another bird forsook two eggs of her own, because that of the cow-bird was taken away,—which proves that there is no accounting for tastes. The blue bird, which exhibits a strong attachment to its breeding places, affords one of the few examples of a species not refusing to lay after the stranger's egg has been first deposited. Mr Pickering observed two nests of the blue-eyed yellow warbler, in which, previous to their own laying, an egg of the cow-bird had been deposited, and finding themselves unable to eject it, the warblers buried it in the bottom of the nest, by building over it an additional story! The egg of the cow-bird, perhaps from being larger, and coming thus into closer contact with the body of its nurse, is sooner hatched than the others. The produce of the latter, though often stifled, are sometimes reared along with the intruder. If the natural offspring die, they are found lying at some distance from the nest, and not directly beneath it, which shows that they are carried out by the parents, and not heaved over by the giant intruder, as in the case of our European cuckoo. When fully fledged, the cow-bird soon deserts his foster-parents, and skulks for a time about the woods, till he instinctively joins a few of his own blood, and then he seeks his food more boldly (five or six together), in the fields and lanes.[1] This bird measures about seven inches in length. The head and neck are blackish-brown, the rest black, glossed above with green, and on the breast with violet.

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'The Baltimore oriole is another beautiful species of Icterus,—*I. Baltimorus*. The male is orange, with the head, neck, upper part of the back, and greater portion of the wings, black. It winters in South America, but makes its appearance in the United States in spring, where its arrival is hailed as the sure harbinger of warmth and sunshine. Full of life and activity, it is seen vaulting like a fiery sylph among the boughs of lofty trees, vanishing with restless inquietude, and again flashing quickly into sight from amidst some wreath of waving foliage, showing like a living gem amid the green adornment of the leafy forest. The most remarkable instinctive feature of this bird is displayed in the structure of its nest, which consists of a pendulous cylindrical pouch of six or seven inches in depth, usually suspended almost from the extremity of some lofty drooping branch. The materials, according to Wilson, are flax, hemp, cow-hair, and wool, woven into a complete cloth, the whole being tightly sewed through and through with long horse-hairs, several of which measure two feet in length. The bottom is composed of thick tufts of cow-hair, also sewed, and strengthened with strong horse-hair. The materials, however, vary, and so solicitous is the bird to procure the best that can be possibly obtained, that during the building season the women in the country are under the necessitv of narrowly watching their thread when bleaching.

The genus Oxyrhynchus, Temm., has the conical sharp-pointed bill of the Icteri, but it is shorter than the head. Example, *O. cristatus*, Swainson's *Illustrations*, vol. iii. pl. 49,—a Brazilian species. The genus Dacnis of Cuvier is formed by the *Motacilla cayana* of Linn.

The genus Sturnus, Linn., also resembles the Icteri; but the bill is depressed towards the extremity. There are two European species, one of which, our common starling (*S. vulgaris*), is well known in many parts of Britain, and is remarkable for its gregarious habits, and singular aërial movements. Its glossy black and purple plumage, starred with little spots of white, render it a very ornamental bird; and the great facility with which it may be taught to speak makes it much sought after as a domesticated species. *S. unicolor* inhabits Sardinia and the South of Europe.

Baron Cuvier concludes the conirostral tribe with three well-marked groups, the crows, the rollers, and the birds of paradise.

In the genus Corvus, Linn., the bill is strong, straight, rather long, compressed towards the point, the nostrils covered by stiff, reversed feathers. The plumage, though generally dense and dark, is soft and lustrous, and the species bear so great a resemblance to each other, that, as Mr Macgillivray observes, the most unpractised observer can scarcely fail to distinguish a crow. They also exhibit corresponding instincts, being, if not shy, at least cunning and watchful. They are omnivorous in the fullest sense of the term, and will poke their beaks into every thing

[1] Nuttall, vol. i. p. 178.

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they can find, from a boiled potato to a dead horse. "When searching for food, they betake themselves to open places, walk in a sedate manner, keep a good look out, and on the least appearance of danger fly off to a distance. Their flight is also sedate, moderately rapid, and performed by regular beats. Their cry varies from a hoarse croak to a caw or chatter, and some of them are musical. They nestle in high places, trees, towers, buildings of various kinds, or rocks; and produce from three to nine eggs, which are deposited very early in the season. They repose at night in similar places, and when alarmed by day generally take themselves to heights. Some species are gregarious, others unsocial,—the latter being the more carnivorous; but even they are observed to associate together when a large quantity of food attracts them to a particular place. The sexes do not differ much in external appearance; the male, however, being in general more robust, and having the plumage more glossy. Moulting takes place in the summer months, and is very gradual. Those which are more carnivorous have the faculty of discovering carrion at a great distance, in the same manner as the vultures, which they in some degree resemble in their habits. They are all easily tamed, and may be taught to imitate the human voice so far as to produce a few articulate sounds. In a state of domestication they are much addicted to pilfering, their depredations not being confined to articles of food, but extending to objects in no respect useful to themselves."[1]

Five species of crow occur in Britain, all permanent dwellers, viz. the raven (*C. corax*), the carrion-crow (*C. corone*), the hooded crow (*C. cornix*), the rook (*C. frugilegus*), and the jackdaw (*C. monedula*). We shall not describe the external aspect of these birds, which, we doubt not, are familiar to our readers. The raven in a state of nature is remarkable for his great cunning and sagacity, while in the domesticated condition he is extremely frolicsome and full of humour. We have seen one that, while engaged in amusing himself with a poodle dog, and unable to keep pace with his four-footed play-fellow, would seize him by a lock of hair, and hold on tenaciously while the dog was careering at full gallop; and his numerous devices, with a view to conceal the remnants of his own food, or appropriate that of others, were varied and unceasing. This species is widely spread over the temperate and northern parts of Europe and America, and in the minds of the ignorant is usually regarded with some degree of superstitious terror. In summer, when the sky is serene, he flies in circles in the higher regions of the clear blue sky, and his deep and solemn croak may be heard at a great distance; but he is said to be sometimes also seen in the midst of thunder-storms, with the electric fire streaming from the point of his bill!—an extraordinary phenomenon certainly (if true), sufficient to terrify the superstitious, and to stamp its subject with the character of a restless and indestructible demon.

The carrion-crow, and the hooded species, are so like in size and structure, that it would be scarcely possible to distinguish them, but for the partially gray plumage of the latter; and as a black and a gray crow are often seen together, some naturalists incline to the belief that they are actually the same. Their geographical distribution, however, seems to differ; the gray kind, though common in Britain and the continental countries of Europe, being unknown in America, where, at the same time, the carrion-crow is described as identical with our own; while, on the other hand, we find the latter extremely rare in the north of Italy, where the hooded crow abounds. The jackdaw and the rook seem unknown in the western world.

The magpies (genus Pica, Cuv.) are of smaller dimensions than the crows properly so called, and their tails, instead of being either round or square, are long and graduated. Their dispositions, however, are equally omnivorous, and they are distinguished by the same sly and furtive cunning. There is only a single European species, our common British kind (*C. pica*, Linn.), which occurs all over Europe, and is well known in North America, and some parts of Asia. Many beautiful species occur in China, and other eastern countries, such, for example, as the red-billed pie, *P. erythrorhyncha*, Gould. Its size exceeds that of our common kind, and the great length of its tail bestows upon it a still more slender and elegant aspect. The prevailing colours are blue, with bars of black and white. It is often kept in aviaries, where it is highly esteemed, on account both of its docility and beauty. This species likewise inhabits the Himalaya Mountains, and there is reason to believe that it is fierce and tyrannical in a state of nature. Mr Shore states, that one which he kept in captivity, although it refused other food, pounced ferociously upon living birds, which were presented by way of experiment, and eagerly devoured them. When seen amid the foliage of trees, it forms an ornamental and conspicuous object, flitting from bough to bough, its long and flowing tail waving in the wind, and its whole form full of vivacity and grace.[2] The Chinese magpie (*P. sinensis*), made known by the researches of General Hardwicke, seems widely extended over tracts of land of very various character as to height and situation. It inhabits the higher portions of the Himalayas, the plains at the base of those mighty mountains, and a great part of the Chinese empire.

The beautiful jays (genus Garrulus, Cuv.) are very nearly allied to the magpies, but the tail is not so lengthened, and the culmen of the under mandible is rather more convex. Our British species (*G. garrulus*) is one of the most ornamental of our indigenous birds. It dwells in woods, beyond the outskirts of which it seldom wanders. Its food consists of insects, fruits, and forest seeds. Species of this little group are found in every quarter of the known world except New Holland. The blue jay of America (*G. cristatus*, Plate CCCXCII. fig. 4) is an almost universal inhabitant of the western woods, frequenting the thickest *settlements*, as well as the deepest recesses of the unpeopled forest,—where his harsh voice often alarms the watchful deer, to the mortification of the disappointed huntsman. This species is a bitter enemy to owls, one of which he no sooner discovers than he summons the whole feathered fraternity to his assistance, and the united mob proceed to vent their indignant spite against the blinking solitary, in the most wrathful and unmeasured manner. But this jay himself cannot be held guiltless of the most owl-like depredations,—for he becomes in his turn the very tyrant he detested, and sneaks through wood and thicket, plundering every nest his poking bill can reach to, gobbling up the eggs, tearing the callow young to pieces, and spreading not only fear, but death, and sorrow, its sad concomitant, around him. Another very ornamental species—

> Proud of cærulean stains
> From heaven's unsullied arch purloined,

is that mentioned by Pallas as having been shot by Steller when Behring's crew landed upon the coast of America. It is the *Corvus Stelleri* of Latham, by whom it was first described from a specimen in Sir Joseph Banks's collection from Nootka Sound. A larger and most magnificent bird is the Columbia jay (*Garrulus Bullokii*, Wagler,—*G. gubernatrix*, Temm.), figured in Mr Audubon's splendid work. The colour is bright blue, with a lofty crest of separate plumes, the throat and breast black, the abdomen whitish,

[1] Macgillivray's *British Birds*, i. 496.

[2] *Century of Birds from the Himalaya Mountains*, plate xli.

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and two of the central tail-feathers extending far beyond the others. It occurs chiefly in Mexico and California.[1]

In the genus CARYOCATACTES, Cuv., both mandibles are equally pointed, and straight to the tips. The only species known in Europe, called the nut-cracker (*C. nucifraga*), is an occasional visitant of Great Britain. Two others have of late years been discovered in Asia, one of which is figured by Mr Gould. They are all believed to inhabit forests, especially those of mountainous countries, whence at certain seasons they emigrate in large flocks. In their climbing tendencies they make an approach to the habits of the woodpeckers.

The limited genus TEMIA, Vail., with the lengthened tail and general proportions of the magpies, has the bill elevated, the upper mandible bulged, and its base covered by short velvety feathers. Example, *Corvus varians*, Lath. (*Phenotrix temia*, Horsfield), of which the general plumage is bronzed green, the head black. It occurs in Java and elsewhere.

In the genus GLAUCOPIS, Forster, the bill resembles that of the preceding; but its base bears a pair of fleshy caruncles. *G. cinerea* is the only known species. It is a native of New Zealand, and was discovered during Captain Cook's voyage. Its flesh is excellent. It is the cinereous wattle-bird of Shaw. M. Temminck joins this and the preceding genus into one.

In the genus CORACIAS, Linn., containing the rollers, the bill is strong, compressed towards the point, which is slightly curved, and the nostrils are oblong, not covered by the feathers, but placed at their margin. The feet are short and strong. These birds are confined to the ancient continents, and are remarkable for their beauty of plumage, of which the colours are usually different shades of purple, blue, and green. They are said to be wild and unsociable, feeding on insects, and keeping themselves concealed in the retirement of thick forests. The European species (*Coracias garrula*, Linn.) has been sometimes seen in Britain. The specimen in the Edinburgh Museum was killed at Dunkeld. Although rare in France, it is by no means uncommon in Sweden, where we would not expect to find a species characteristic of the south of Europe, and which is believed to winter in Barbary and Senegal. It is not unfrequent in the gardens of Rome, and is common in the Morea. It becomes very fat in autumn, and is much sought after during that season as an article of food, especially by the inhabitants of the Cyclades. Several other kinds occur in Africa and the East. Of these the Abyssinian species is distinguished by the elongation of the lateral feathers of the tail. The Madagascar roller, and some allied kinds, distinguished by a shorter, more arched, and greatly broader bill, belong to the genus COLARIS, Cuv., synonymous with *Eurystomus* of M. Vieillot.

The genus PARADISEA, Linn., with which we conclude our abridgment of the conirostral tribe, contains the famous birds of paradise, so noted during our early intercourse with eastern countries. The bill is straight, compressed, rather strong, unnotched, the nostrils surrounded by a close tissue of feathers of a velvet texture, sometimes resplendent with metallic lustre. (See Plate CCCXCII. fig. 8.) These birds are native to New Guinea and the neighbouring islands, and in consequence of the delicately graceful structure of their plumage, and the pure and beautifully blended colours by which they are adorned, the species in general may be regarded as the most highly prized of all the feathered race. Their history was long obscure as night, and even now we have but few features of their character developed by the actual observation of trustworthy witnesses. We cannot be here expected to throw any new light upon the subject; but we shall give a portion of the information which we have acquired from various authors.

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In the second edition of Pennant's *Indian Zoology*, there is a general description of the genus from Valentyn and other writers, by Dr J. R. Forster, preceded by a learned disquisition on the fabulous phœnix of antiquity, a bird of the size of an eagle, decorated with gold and purple plumes, and more particularly described by Pliny as being characterized by the splendour of gold around the neck, with the rest of the body purple, the tail blue varied with rose-colour, the face adorned with combs or wattles, and the head furnished with a crest. This excellently adorned phœnix Dr Forster very properly supposes to have been no other than a symbolical Egyptian illustration of the annual revolution of the sun, and the conversion of the great year, which, according to Manilius, corresponds with the supposed life of the phœnix, and from which period the same course of seasons and position of the heavenly bodies are renewed. Now, though it is certain, as Dr Forster observes, that the birds of paradise were never known to ancient writers, and that whatever the Egyptian priests delivered concerning their fabulous phœnix has no apparent agreement with the birds in question, yet it is remarkable enough that the names applied to them, both by Indian and European nations, attribute something of a supposed celestial origin. Dr Shaw, however, thinks that this notion has in all probability arisen merely from their transcendent beauty, and the singular and delicate disposition of their plumage. The Portuguese who navigated to the Indian islands called them *Passaros da Sol*, in like manner as the Egyptians regarded their imaginary bird as symbolizing the annual revolution of that great luminary. The inhabitants of the island of Ternate call them Manuco-Dewata, or the Birds of God.[2]

The great bird of paradise (*Paradisea apoda*, Linn., so called from its supposed want of legs), the first of the genus made known to Europeans, was imported about the year 1522, by Antony Pigafetta, who accompanied Magellan in his voyage round the world. Pigafetta was satisfied by ocular demonstration from the first, that this bird, like every other, was supplied with legs, but that the natives cut them off, as parts of no importance. In consequence, however, of this prevailing if not universal mutilation, a notion soon obtained in Europe that the bird was naturally destitute of these common-place but useful organs, and that consequently it floated for ever in the air, winnowing with loving wings the gentle breezes, or at times suspending itself for a few brief moments from some lofty sun-illumined tree, by the two peculiar lengthened filaments with which it is adorned. In accordance with this belief, it was of course consistent to suppose, that whatever individuals were obtained "on this dim spot which men call earth," had fallen from their aërial heights immediately before their dissolution. Even Aldrovandus, the most zealous naturalist of his age, having himself seen only such specimens as had been mutilated in the usual manner, accuses Pigafetta of audacious falsehood in asserting that the bird was naturally furnished both with legs and feet; and the great Scaliger, himself a naturalist of no mean order, gave equal credit to this foolish fancy.

The true residence or breeding-place of these birds seems to be Papua or New Guinea, from whence they make occasional excursions to some smaller neighbouring islands. They fly in flocks of about thirty or forty, led, it is alleged, by a single bird which the natives call their king, but which is said to be of a different species. It is further pretended, that when this bird settles, the whole flight settle also, in consequence of which they sometimes

[1] *The Birds of America*, plate xcvi.

[2] Shaw's *General Zoology*, vol. vii. p. 479.

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perish, being unable to rise again owing to the peculiar structure of their wings. They also always fly against the wind, lest their flowing plumage should be discomposed. While flying they make a noise like starlings, but their common cry rather resembles that of a raven, and is very audible in windy weather, when they dread the chance of being thrown upon the ground. In the Aru Islands they are seen to perch on lofty trees, and are variously captured by the inhabitants, with bird-lime, snares, and blunted arrows. Though many are taken alive, they are always killed immediately, embowelled, the feet cut off, the plumed skins fumigated with sulphur, and then dried for sale. The Dutch ships frequenting the sea between New Guinea and Aru, a distance of about twenty miles, not unfrequently observe flocks of paradise birds crossing from one to the other of these places, but constantly against the wind. Should a gale arise, they ascend to a great height, into the regions of perpetual calm, and there pursue their journey. With respect to their food we have little certain information from the older authors, some of whom assert they prey on small birds, a supposition which Dr Shaw inclines to think is favoured by their strength of bill and legs, and the vigour with which they act in self-defence. They are also said to feed on fruits and berries; and Linnæus says they devour the larger butterflies.[1]

We owe the following observations to M. Gaimard, one of the naturalists who accompanied the expedition of Captain Freycinet, and who having had an opportunity of seeing several living birds of paradise in the island of Waigiou, has furnished us with some interesting details. He says that they appear to prefer to all other places the most dense and secluded portions of the forests. When the heavens are clear, they perch habitually on the summits of the tallest trees. They fly with rapidity, but in an undulating manner, as is usual with birds which are adorned with long decomposed or disunited feathers; and he confirms the old account, that the luxuriant length of their superb plumage induces them always to fly in the direction from which the wind proceeds. "Cette manœuvre," he observes, "est pour eux très-naturelle, puisqu'elle maintient les longues plumes appliquées contre le corps; dans une direction contraire, le vent ne manquerait pas d'étaler et de relever ces plumes, et il en résulterait nécessairement un grand embarras dans le jeu des ailes." Their total disappearance on the approach of any storm or tempest shows their conscious weakness. In other respects, however, they are courageous, and even vindictive, pursuing fiercely any supposed enemy, however superior to themselves in strength of bill and talons. There is no instance, Captain Freycinet supposes (we now know he does so erroneously), of their being ever reduced to the domestic state; and they are never found caged by any natives of the Papous, where they are by no means rare, and where their skins form the principal object of commercial exchange between the insular inhabitants and the Chinese Indians or eastern Europeans. Authors (we speak not of those who assert that birds of paradise are nourished by dew, or by the perfume which exhales from fruits and flowers) have assigned different diets to these birds. Some say that they search for fruits and nectarous juices; others that they capture insects, and such small prey. There is truth in both statements, for it seems ascertained that they feed alike on fruits and insects. As to all those anxious interesting cares which precede, accompany, or follow incubation,—these and many other important particulars in their history are still unknown. The natives of New Guinea, in preparing the skins, content themselves by removing the fleshy mass of the body, and cutting off the two wings and legs. They then pass a piece of stick through the mouth downwards to the tail. Few of the museums of Europe contain any other specimens than these mutilated remains, which the gorgeous flowing feathers of the sides render still worthy of admiration, however unfit to convey a true idea of the natural state.

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We shall next extract some interesting information from a work by M. Lesson, one of the few European naturalists who have had an opportunity of beholding these extraordinary creatures in their native haunts. "Les paradisiers ou du moins l'éméraude, seule espèce sur laquelle nous possédons des renseignemens authentiques, vivent en bandes dans les vastes forêts du pays des Papous, group d'îles situées sous l'équateur, et qui se compose des îles Arou, de Waigiou, et de la grande terre nommée Nouvelle-Guinée. Ces sont des oiseaux de passage qui changent de district suivant les moussons. Les femelles se réunissent en troupes, s'assemblent sur les sommités des plus grands arbres des forêts, crient toutes à la fois pour appeler les mâles. Ceux-ci sont toujours solitaires au milieu d'une quinzaine de femelles qui composent leur sérail, à la manière des gallinacées.

"J'extrairai de mon journal inédit les détails suivans, relatifs aux oiseaux de paradis: ils ont été écrits sur les lieux. *Journal Ms.*, t. vi. p. 19 et suiv. Les *oiseaux de paradis*, à l'exception de deux espèces, nous étaient apportés par les Papous, ce qui établit entre eux et nous un commerce actif d'échange. Je me procurai l'éméraude, le manucode, le loriot paradis orangé, le sifilet, le superbe, les épimaques proméfils, et à paremens frisés, le magnifique, et le rouge. La quantité que les naturels de ces contrées apportaient à bord de la corvette la *Coquille* doit faire supposer que ces oiseaux, si estimés en Europe, y sont singulièrement multipliés. Le manucode se présenta deux fois dans nos chasses, et nous tuâmes le mâle et la femelle. Cette espèce paraît monogame, ou peut-être n'est elle isolée par paires qu'au moment de la ponte. Dans les bois cet oiseau n'a point d'éclat; son plumage rouge de feu ne le décèle point, et sa femelle n'a que des teintes ternes. Il aime à se tenir sur les arbres de teck, dont le large feuillage l'abrite, et dont le petit fruit forme sa nourriture. Il a l'iris brun, et les pieds d'un bleu d'azur très tendre. Les Papous le nomment *saya*. Dès les premiers jours de notre arrivée sur cette terre de promission (la Nouvelle-Guinée) pour le naturaliste, je fus à la chasse. A peine avais-je fait quelques centaines de pas dans ces vieilles forêts, filles du temps, dont la sombre profondeur est peut-être le plus magnifique et le plus pompeux spectacle que j'aie jamais vu, qu'un oiseau de paradis frappa mes regards; il volait avec grâce et par ondulations; les plumes de ses flancs formaient un panache gracieux et aérien, qui, sans hyperbole, ne ressemblait pas mal à un brillant météore. Surpris, émerveillé, éprouvant une jouissance inexprimable, je dévorais des yeux ce magnifique oiseau; mais mon trouble fut si grand que j'oubliai de le tirer, et que je ne m'aperçus que j'avais un fusil que lorsqu'il était déjà bien loin. On ne pourrait guère avoir une idée exacte des paradis d'après les peaux que les Papous vendent aux Malais, et qui nous parviennent en Europe. Ces peuples chassèrent primitivement ces oiseaux pour décorer les turbans de leur chefs. Ils les nomment *mambéfore* dans leur langue, et les tuent pendant la nuit, en grimpant le long des arbres où ils se couchent, et les tirant avec des flèches faites exprès et très courtes, qu'ils façonnent avec le rachis des feuilles d'un latanier. Les campongs ou villages de *Mappia* et d'*Emberbakène* sont célèbres par la quantité des oiseaux qu'ils préparent, et tout l'art des habitans se borne à leur arracher les pieds, à les écorcher, à leur fourrer un bâtonnet à travers du corps, et à les dessécher à la fumée. Quelques uns plus adroits, et sollicités par les trafiquans

[1] Shaw's *General Zoology*, vol. vii. p. 482–4.

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Chinois, les desséchent avec les pieds. Le prix d'un oiseau de paradis chez les Papous de la côte est au moins d'une piastre, et ces peuples préfèrent l'argent à tout autre objet, même à du fer travaillé.

" Nous tuâmes, pendant notre séjour à la Nouvelle-Guinée, une vingtaine de ces oiseaux, que je préparai pour la plupart. Ils appartenaient à diverses personnes de l'expédition, et notamment au capitaine. Je n'en avais point encore, lorsque M. Bérard, lieutenant de vaisseau, zélé pour les collections que je formais en simple particulier, et à mes frais, pour le Muséum, et pour remplir la promesse que j'avais faite au ministère, en m'embarquant, de recueillir les objets d'histoire naturelle, voulut bien m'en remettre un pour la collection. Depuis, j'en achetai un second d'un homme de l'équipage, que je lui payai 150 francs. J'en tuai ensuite un avec un grand nombre de femelles : on les voit au Muséum.

" L'éméraude en vie est de la taille du geai de France ; son bec et ses pieds sont bleuâtres ; l'iris est d'un jaune éclatant ; ses mouvemens sont vifs et agiles ; il ne se perche communément que sur le sommet des plus grands arbres. Lorsqu'il en descend, c'est pour manger les fruits de quelques arbres moyens, ou lorsque le soleil, dans toute sa force, lui fait un besoin de chercher de l'ombrage. Il affectionne certains arbres, et fait retentir les environs de sa voix perçante. Son cri lui devint fatal, parce qu'il nous indiqua les allures de cet oiseau. Nous l'épiâmes, et c'est ainsi que nous parvîmes à en tuer ; car, lorsqu'un paradisier mâle est perché, et qu'il entend bruiser dans le silence de la forêt, il se tait et ne bouge plus. Son cri d'appel est un *voike, voike, voike, voiko*, fortement articulé. La femelle a le même cri, mais elle le pousse d'une manière bien plus faible. Celle-ci, déchue du brillant plumage de son époux n'a que de sombres atours. Nous en rencontrions à chaque arbre des vingtaines réunies, tandis que les mâles, toujours solitaires, n'apparaissaient que rarement.

" C'est au lever du soleil et à son coucher que l'oiseau de paradis va chercher sa nourriture. Dans le milieu du jour, il se tient caché sous le large feuillage du teck, et n'en sort point. Il semble redouter l'action des rayons brûlans de cet astre, et ne point vouloir s'exposer aux atteintes d'un rival. Nous apprîmes, par une longue expérience, à imiter la ruse de ce bel oiseau ; mais le zéle des tueurs de paradisiers était si grand que personne ne voulait tirer sur aucun autre oiseau de peur de les effaroucher, et que, réduit à peu près à mes seules ressources, le tribut que quelques personnes me donnaient de leur chasse fut bien diminué ; plus curieux, dans l'intérêt de la science, d'un petit volatile inédit, que de posséder plus ou moins de dépouilles d'une espèce connue, bien que prisée, je ne guettai des paradis que pendant quelques jours, et tuai d'ailleurs toute espèce qui arrivait à ma portée.

" Pour chasser les oiseaux de paradis, les voyageurs appelés à visiter la Nouvelle-Guinée doivent se rappeler qu'il est nécessaire de partir dès le matin du navire, d'arriver au pied de l'arbre de teck ou du figuier, que ces oiseaux recherchent à cause de leur fruit (notre séjour a eu lieu du 26 Juillet au 9 Août), avant quatre heures et demie du matin, et de rester immobile jusqu'à que quelques mâles, pressés par la faim, viennent sur les branches qu'on aura jugé à distance convenable. Il est indispensable de posséder un fusil à très longue portée, et chargé à gros plombs, car il est fort difficile de tuer roide un *éméraude*, et s'il n'est que blessé, il est bien rare qu'il ne soit pas perdu pour le chasseur, dans des fourrées tellement épaisses, qu'on ne peut y reconnaitre son chemin sans une boussole.

" Le paradisier petit éméraude mange sans doute de plusieurs substances dans son état de liberté. Je puis affirmer qu'il vit de graines de teck, et d'un fruit nommé *amihou*, blanc rosé, de saveur fade et mucilagineuse, de la grosseur d'une petite figue d'Europe, et qui appartient à un arbre du genre *ficus*. Ces fruits plaisent à beaucoup d'oiseaux, car ils sont aussi recherchés par les *calaos*, les *manucodes*, et les *cassicans calibé* et *phonygame*.

" J'ai vu deux oiseaux de paradis conservés dans une cage, depuis plus de six mois, par le chef des commerçans Chinois, à Amboine. Ils étaient toujours en mouvement, et on les nourrissait avec du riz bouilli ; mais ils aimaient surtout les cancrelas (*blatta*). Ce Chinois me les fit 500 francs pièce ; alors, sans argent, et n'ayant point de crédit dans cette île, je ne pus réclamer ma solde, et ce fut en vain que j'offris des objets de valeur à ce trafiquant opulent, il fut sourd à mes prières. Pourquoi, sur l'argent que nous possédions à bord, pour frais accidentels, et qu'on a retourné à Paris, ne pas avoir acheté, pour le destiner à la France, un de ces magnifiques oiseaux, qui serait peut-être mort en route, mais dont les habitudes vivaces, et analogues à celles de nos pies, nous donnaient tant de chances de succès ?"[1]

We shall conclude our miscellaneous extracts in illustration of these birds, by a quotation from a recent English writer. The principal object of attraction to strangers at Macao is known to be the splendid aviary and gardens of Mr Beale, who, after a residence of forty years in that country, devotes his leisure to the cultivation of many of the most delightful productions of nature, and among these not the least remarkable is the living bird of paradise, as thus described by Mr Bennet. " The specimen in the possession of Mr Beale is a fine male, *Paradisea apoda* of Linnæus, the *P. major* of Shaw. He was at the time I beheld him arrayed in his full and splendid plumage ; he is enclosed in a large and roomy cage, so as not by confinement to injure in the slightest degree his delicate and elegant feathers. This beautiful creature has been in Mr Beale's possession nine years, and was originally procured from the island of Bouro (one of the Molucca group), which is situated in about latitude 3° 30′ south, and longitude 126° 30′ east.... The neck of this bird is of a beautiful and delicate canary-yellow colour, blending gradually into the fine chocolate colour of the other parts of the body ; the wings are very short, and of a chocolate colour. Underneath them, long, delicate, and gold-coloured feathers proceed from the sides in two beautiful and graceful tufts, extending far beyond the tail, which is also short, of a chocolate colour, with two very long shafts of the same hue proceeding from the uripigium. At the base of the mandibles the delicate plumage has during one time (according as the rays of light are thrown upon it) the appearance of fine black velvet, and at another a very dark green, which contrasts admirably with the bright emerald of the throat.... The mandibles are of a light blue, irides bright yellow, and the feet of a lilac tint. This elegant creature has a light, playful, and graceful manner, with an arch and impudent look ; dances about when a visitor approaches the cage, and seems delighted at being made an object of admiration ; its notes are very peculiar, resembling the cawing of the raven, but its tones are by far more varied. During four months of the year, from May to August, it moults. It washes itself regularly twice daily, and after having performed its ablutions, throws its delicate feathers up nearly over the head, the quills of which feathers have a peculiar structure, so as to enable the bird to effect this object. Its food, during confinement, is boiled rice mixed up with soft egg, together with plantains, and living insects of the grasshopper tribe ; these insects, when thrown to him,

[1] *Manuel d'Ornithologie*, t. i. p. 387.

Insessores. the bird contrives to catch in his beak with great celerity; it will eat insects in a living state, but will not touch them when dead.

"I observed the bird, previously to eating a grasshopper given him in an entire or unmutilated state, place the insect upon the perch, keep it firmly fixed with the claws, and divesting it of the legs, wings, &c. devour it, with the head always placed first.....It rarely alights upon the ground, and so proud is this creature of its elegant dress, that it never permits a soil to remain on it; and it may be frequently seen spreading out its wings and feathers, and regarding its splendid self in every direction, to observe whether it is in an unsullied condition."[1]

Dr Shaw alludes to an instance of the bird of paradise having been brought alive to England. It had, however, entirely lost the beautiful floating feathers which render its body apparently so light and buoyant, and did not long survive its arrival in our murky clime.

Although there are not above seven distinct species of these birds, they have been formed into no less than four separate genera by M. Vieillot. The most anciently known is the kind called in English books the great or common bird of paradise, *l'éméraude* of the French, *P. apoda*, Linn. to which most of the preceding memoranda may apply. (See Plate CCCXCII. fig. 6.) It is of a cinnamon colour, the upper part of the head and neck yellow, the front and throat emerald green, or black. It is the male of this species which bears the long, floating, yellow plumes so prized as articles of commerce, with a view to ornament in dress. Although the body is no larger than that of a thrush, the total length is two feet. In the red paradise bird (*P. rubra*) the head and throat are emerald-green, the back and front of the neck orange yellow and velvety, the throat chesnut or cinnamon colour, and the long feathers of the flanks brilliant carmine red. The two peculiar barbless shafts which proceed from the base of the tail, are broad, flattened, twisted, and of a brownish-red colour. These belong to the restricted genus PARADISEA.

The six-shafted paradise bird (*P. sexsetacea*, Shaw,—*P. aurea*, Gmel.) is black, with the throat of golden green, and three prolonged setaceous feathers proceeding from behind each eye, and terminating in a little expanded disk of golden green. It forms the genus PAROTIA of Vieillot. We shall merely add, that *P. superba* constitutes the genus LOPHORINA,—*P. regia* that called CICINNURUS,—and *P. nigra*, Gmel., another named ASTRAPIA. The whole are figured by Buffon, Vaillant, or Vieillot, and their singular forms, gorgeous colouring, and exquisite structure of plumage, render them deserving of the most attentive consideration on the part of all admirers of nature.

TRIBE 4TH.—TENUIROSTRES.

Baron Cuvier here places a variety of generic groups which agree chiefly in possessing a slender lengthened bill, sometimes straight, sometimes considerably curved. According to the structure of the tongue, which in several genera is not yet distinctly known, they feed either on insects or the nectarous juices of fruits and flowers,—a few, such as the humming-birds, combining both these habits.

In the genus SITTA the bill is straight, pointed, compressed at the extremity, and the tongue short and corneous. The species called *nut-hatches* climb along the bark of trees with extraordinary facility, not only upwards, like the woodpeckers, but downwards, and in all directions. The European species (*S. Europea*), though a constant resident in Britain, is rather rare in most localities. It breeds in hollow trees, not seldom using the deserted habitation of a woodpecker, the opening into which it contracts by means of a wall of clay. The female sits very close during incubation, and instead of flying off when approached, she will utter a hissing sound, and make a show of striking at the intruder with her bill and wings. Sir W. Jardine some time ago enjoyed an opportunity of observing a brood which had been taken young. They became remarkably tame, and when released from their cage, would run over their owner in all directions, poking into seams and pockets, as if in search of food upon some goodly tree, and uttering from time to time a low and plaintive cry. In climbing, they rest much upon the tarsus, but never use the tail. Several true nut-hatches occur in North America, but Pennant erred in supposing that the European species was likewise indigenous to the new world. Insessores

In the genus XENOPS of Illiger, the bill is rather more compressed, and the under ridge more convex, while in ANABATES of Temm. it is the upper ridge which increases in convexity, so as to approach to that of the thrushes; but the tail in some of the species is long and wedge-shaped, and exhibits a worn appearance, as if it were occasionally used in climbing.

In the genus SYNALLAXIS, Vieil., the bill is straight, not much lengthened, considerably compressed, slender and pointed, and the tail is generally long and acuminate. (See Plate CCCXCII. fig. 7.) We know little of the habits of these birds, except that they are insectivorous, and dwell in forests. Most of the species are from South America, and to these it is probable that the generic term should be restricted.

The old genus CERTHIA of Linnæus was characterized by an arched bill, but the species possessed but little else in common, and have been therefore formed into several minor groups. The true or restricted creepers (CERTHIA, Cuv.), so called from their habit of running round the trunks of trees, have the bill of medium length, curved, compressed, slender, sharp pointed. The tail is wedge-shaped, and composed of stiff, deflected feathers. Our well-known British species (*C. familiaris*) is the only example of the genus found in Europe, and it is in fact doubtful whether there is any other elsewhere. The North American creeper seems identical, but the numerous other birds described as creepers do not belong to the genus Certhia. The solitary type alluded to is a retired inhabitant of the woods, in no way conspicuous in colour, though pleasingly mottled above with black, brown, and grayish white; and being of small size, and seldom showing itself in open places, is deemed rarer than it really is. Though of a somewhat lengthened form, it is probably, with the exception of the golden-crested wren, the smallest bodied British bird. It is said to feed entirely upon insects, although as a winter resident in many frost-bound regions, we shall not aver that it never swallows seeds. It builds in the hollows of trees, and may be often seen during the delightful autumn, when the rustling woods are fragrant with fallen leaves, flitting from the top of one trunk to the bottom of another, which it ascends by a kind of spiral progression, and then darting downwards to a neighbouring tree, it thus busily pursues from time to time its interrupted flight. This bird chiefly shows itself in our shrubberies and wooded pleasure-grounds in winter.

In the genus DENDROCOLAPTES, Hermann, the tail resembles that of the preceding, but the bill is much stronger, and enlarged at the base. In certain species it is greatly curved. (Plate CCCXCII. fig. 9.) These birds are American, and are usually characterized by a reddish plumage. In TICHODROMA, Illiger, the tail does not present a worn appearance at the point, although the best known, if not the only species, runs up rocks with great agility. The bill is long, slender, triangular, and depressed at the base.

[1] *Wanderings in New South Wales*, &c. vol. ii.

Insessores.

The European species, called by us the wall-creeper (*T. phœnicoptera*, Temm.,—*Certhia muraria*, Gmel.), inhabits the southern countries of Europe, where it dwells among lofty and precipitous rocks. It is well known among the Swiss Alps, and the mountainous parts of Spain and Italy, where it is said to prey much on spiders and their eggs.

In the genus NECTARINIA of Illiger, the bill is arched, pointed, and compressed, resembling that of the creepers, with which the species were so long conjoined; but they do not climb, and their habits, if the name is properly applied, are not so much insectivorous as honey-sucking. They are all exotic. The term *guit-guit* is given by the French to certain small species, of which the plumage of the males is very rich and lustrous. Their tongue is bifid and filamentary. Such are *Certhia cyanea*, *cerulea*, &c. Some species of larger size and less adorned plumage, and of which the tongue is short and cartilaginous, have been separated from the others. Such is a South American species, the *Merops rufus* of Gmelin, as large as a nightingale, of a reddish colour above, the throat whitish. It constructs a covered nest, and serves as the type of Temminck's genus OPETIORHYNCHUS.[1]

The genus DICÆUM of Cuv. has the bill longer than the head, sharp, curved, depressed, and broadened at the base. The species are of small size, and usually ornamented with portions of scarlet. They are natives of the East Indies. In MELITHREPTUS of Vieillot, the bill is extremely long, and curved almost into a semicircle. Of this form the hook-billed creeper, *Certhia vestiaria*, Shaw, affords a good example. (Plate CCCXCIII. fig. 2.) It is a native of the Sandwich Islands, where it is much valued on account of its plumage, which affords the principal material in the formation of those gorgeous scarlet mantles worn by chiefs and persons of distinction.

The *souimangas* (a Madagascar name, signifying sugar eaters, genus CINNYRIS, Cuv.) have the bill long, slender, and finely toothed along the edges. The tongue is capable of considerable extension, and terminates in a small bifurcation. The species are widely dispersed over all the southern regions of the old world (Africa, the Indian Archipelago, &c.), and seem in those countries to represent the beautiful humming-birds of the western world. Indeed these tribes greatly resemble each other both in form and habits. The souimangas are subject to a double moult, which occasions a considerable diversity in the plumage even of the same species, according to the season of the year; and hence our knowledge of this, as of several other sumptuous groups, though sufficiently voluminous, is probably not yet remarkable for its accuracy. Several splendid works, however, have been devoted, either in whole or in part, to its illustration.[2] The nuptial plumage is remarkable for its golden lustre, and the richness and variety of its innumerable iridescent hues; but after the termination of the breeding season, a much more humble garb is assumed, and many a *bizarre* appearance is presented by the intermediate links of that changeable costume which connects the holiday-suit of spring with the more quaker-like attire of autumn. Hence the difficulty of distinguishing in many birds, between a specific difference and an individual variation, more especially where foreign species are concerned; for in such instances we have seldom a prolonged opportunity of verifying our observations on external characters, by an examination of natural habits and instinctive modes of life. Yet it is only by ascertaining the uniformity presented by all these circumstances in a variety of individuals, that we are enabled to trace out the exact limits of specific identity. Several species of Cinnyris occur in India, but the greater proportion are of African origin, and may be said to form the most signal and admired feature in the Ornithology of that country.

Insessores.

In the greater number the tail is equal. Of these we may name the superb creeper (*C. superba*), described and figured in the magificent work of M. Vieillot. Its length is six inches; the crown of the head, upper part of the neck, smaller wing-coverts, back, and rump, are bright-greenish gold; across the upper part of the breast runs a bar of bright gilded yellow, beneath which the whole under parts are deep brownish crimson; the wings and tail are blackish brown, the legs are also brown, the bill is black. This beautiful species was discovered at Malimba, in Africa, by M. Perrein. Another highly adorned species, such "as limners love to paint, and ladies to look upon," is the *Certhia splendida* of Shaw (*C. afra* and *lotenia*, Linn.?). It usually occurs in woody places, and, in addition to its splendid plumage, is said to be worthy of admiration for its musical powers,—its song being by some esteemed equal to that of the nightingale. The spotted breasted Cinnyris (*C. maculata*) also dwells in the forests of Malimba, and frequently approaches the habitations of the natives, allured by the flowers of the Cytisus cajan, commonly called the congo pea, which, according to Dr Shaw, is much cultivated by the negroes.

In some of these birds the central feathers of the tail are lengthened in the males. Such is *C. violacea*, a Cape species, which likewise dwells in woods, and is said to build a nest of a singularly elegant construction. In a few the bill is almost straight, as in *C. rectirostris*, Vieillot. Our restricted limits will not admit of our expatiating on this delightful group.

The genus ARACHNOTHERA of Temm. has the long arcuated bill of the souimangas, but it is of stronger structure, and wants the dentations, and the tongue is short and cartilaginous. The species (such as *A. longirostra* and *inornata*, Temm. *Pl. Col.* 84, figs. 1 and 2), so far as yet known, inhabit the Indian islands, and prey on spiders.

The genus TROCHILUS, Linn., contains the true humming-birds, a numerous group of fairy and fantastic forms, which inhabit both continents of America, and some neighbouring islands, but are altogether unknown in the ancient world. The bill is long and slender, but in its range throughout the entire species exhibits considerable modification, being in some nearly straight, in others curved, and in a few turned upwards. Such as are characterized by an almost straight bill constitute the genus ORNISMYA, Lesson (*Orthorhynchus*, Lacepede), Plate CCCXCIII. fig. 1; while those in which it is more or less bent remain under the ancient name of TROCHILUS, *Ibid.* fig. 6. The tongue is long and extensile, and is usually described as being composed of two muscular tubes united for the greater part of their length, and broadening towards the point into a spoon-like portion. Sir W. Jardine, on relaxing a specimen of *T. moschitus*, observed the appearance of a fimbriated opening at the tip, the outer margin of each division being beset with recurved, sharp-pointed, pliable spines, while in all that Mr Swainson examined the two filaments were perfectly flat. Their feet are extremely small, their wings long and narrow, their tails comparatively broad,—whilst their shortened humerus and very large unnotched

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[1] The generic name of *Nectarinia* was bestowed by Illiger upon those foreign creepers known by the terms *guit-guits* and *souimangas*, but it has been applied more exclusively by Cuvier to the former, and by Temminck to the latter. The souimangas, on the other hand, fall into Cuvier's genus *Cinnyris*, while the guit-guits are placed in the genus *Cœreba* by Temm. These transpositions, as we have already remarked, are extremely perplexing.

[2] Vaillant, *Hist. Nat. des Oiseaux d'Afrique*, 5 vols in 4to, 1799, and subsequent years,—and Audebert, *Oiseaux dorès, ou à reflets métalliques*, 2 vols. fol. Paris, 1802. A continuation of the latter work has been published by M. Vieillot.

Insessores. sternum exhibit osteological features in relation to the power of flight resembling those of swifts. The beauty of their plumage, if equalled, is certainly unsurpassed among the feathered tribes.

Humming-birds, in general, may be said to inhabit chiefly the intra-tropical regions of America, including the West Indies; but that they are capable of sustaining a considerable reduction of temperature, and of spreading themselves into comparatively rigorous climes, is evident from the observations of Captain King, who in his survey of the southern coasts met with numerous examples of these diminutive creatures flying about in a snow-storm near the Straits of Magellan, and discovered two species in the remote island of Juan Fernandez. Two other hardy species had been long known to migrate during summer far into the interior of North America, viz. the ruff-necked humming-bird (*T. rufus*), discovered during Cook's voyage in Nootka Sound, and since traced by Kotzebue to the 61st degree of north latitude, along the western shores; and the ruby-throated humming-bird (*T. colubris*), which was found breeding by Mr Drummond near the sources of the Elk River, and is known to reach at least as far north as the fifty-seventh parallel. Mr Bullock also discovered several species at a high elevation, and of course a coolish temperature, on the lofty table-lands of Mexico, and in woods in the vicinity of the snowy mountains of Orizaba. The best and most ample history of these "feathered gems" may be gathered from the pages of Wilson and Audubon, while the superb adornment of their beautifully pencilled plumage, so rich in its varied combination of lustrous green and gold, may be studied with advantage in the sumptuous pages of M. Lesson.[1] They are of a most lively and active disposition, almost perpetually upon the wing, and darting from flower to flower with the busy rapidity rather of a bee than a bird. In the uncultivated districts of the country they inhabit the forests, but in peopled regions they flock without fear into the gardens, poising themselves in the air, while they thrust their long extensile tongues into every flower in search of food. According to Bullock, they will remain suspended in a space so small that they have scarcely room to move their wings, and the humming noise which they produce proceeds entirely from the prodigious velocity with which they vibrate these tiny organs, by means of which they will remain in the air almost motionless for hours together. An older writer, Fermin, a physician of Surinam, compares this action to that of the bee-like flies which in still and sultry weather we often see hovering in the vicinity of still waters; and Wilson says, that when a humming-bird arrives before a thicket of trumpet-flowers in bloom, he suspends himself so steadily that his wings become "invisible, or like a mist." They often enter windows, and after examining any fresh bouquets with which fair hands may have decked the table, they will dart like sun-beams out by an opposite door or window. During the breeding season they become jealous of encroachment, and exhibit great boldness in defence of their supposed rights. When any one approaches their nest, they will dart around with a humming noise, frequently passing within a few inches of the intruder's head. A small species called the Mexican star (*T. cyanopogon*) is described by Mr Bullock as exhibiting great intrepidity while under the influence of anger. It will attack the eyes of the larger birds, striking at them with its sharp, needle-like bill; and when invaded by one of its own kind during the breeding season, their mutual wrath becomes immeasurable, their throats swell, their crests, tails, and wings expand, and they fight in the air till one or other falls exhausted to the ground. Indeed old Fernando Oviedo gives a still more alarming statement of their fiery temper. "When they see a man climb ye tree where they have their nests, they flee at his face, and stryke him in the eyes, commying, goying, and returnyng with such swiftness, that no man woulde ryghtly believe it that hath not seen it."[2] Insessores.

Although humming-birds may frequently suck the juices of flowers, those naturalists err who allege that they support themselves exclusively on that natural nectar. "For myself," says Wilson, "I can speak decisively on the subject: I have seen the humming-bird for half an hour at a time darting at those little groups of insects that dance in the air in a fine summer evening, retiring to an adjoining twig to rest, and renewing the attack with a dexterity that sets all our other fly-catchers at defiance." Mr Bullock thinks it probable that all the species eat insects, and he had repeated ocular proof that many of them feed on flies, which they both caught themselves, and used to *steal* from spiders' webs. It was only the smaller kinds, however, that they dared to molest, for the stronger spiders showed fight, on which the besiegers would shoot off with the rapidity of a sun-beam, and could scarcely be discovered but by the luminous glow of their refulgent colours. It may easily be conceived that creatures of such resplendent plumage, in spite of their irascible temper and pugnacious habits, are universal favourites wherever they appear; and that in "the sweet serenity of a summer morning," their visits to the dewy flower-beds of a cottage dwelling are surely welcomed with delight.

> When morning dawns, and the blest sun again
> Lifts his red glories from the eastern main,
> Then through the woodbines, wet with glittering dews,
> The flower-fed humming-bird his round pursues;
> Sips with inserted bill the honey'd blooms,
> And chirps his gratitude as round he roams;
> While richest roses, though in crimson drest,
> Shrink from the splendour of his gorgeous breast.
> What heavenly tints in mingling radiance fly!
> Each rapid movement gives a different dye;
> Like scales of burnished gold they dazzling show,
> Now sink to shade—now like a furnace glow!

In the summer of 1803 a nest of young humming-birds was brought to Alexander Wilson. They were nearly fit to fly; in fact, one of them did fly out of the window the same evening, and falling against a wall, was killed upon the spot. The other refused food, and in consequence of this foolish obstinacy its life next morning was nearly extinct. A lady in the house undertook to be its nurse, and placing it in her bosom, it immediately began to revive, which showed its good taste and natural sense of comfort. She then kindly dissolved a little sugar in her mouth, and thrusting its bill into the same, the creature sucked with great avidity. In this manner it was brought up until fit for the cage. Wilson kept it for three months afterwards, supplying it constantly with loaf-sugar dissolved in water, which it preferred to honey and water. He also gave it fresh flowers every morning, sprinkled with the sugary liquid. It appeared quite gay, active, and full of spirit, hovering from flower to flower as if in its native wilds (alas! it still was caged), and always expressed by its motions and chirping the greatest pleasure at the sight of every fresh supply of flowers. "Numbers of people," says our author, "visited it from motives of curiosity, and I took every precaution to preserve it if possible through the winter. Unfortunately, however, by some means it got at large, and, flying about the room, so injured itself that it soon after died."

Most of the preceding notices apply to the ruby-throated humming-bird (*T. colubris*, Linn.), the species of which

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[1] *Histoire Naturelle des Oiseaux Mouches;—Hist. Nat. des Colibris;—Hist. Nat. des Trochilidés.*

[2] *History of the West Indies*, translated by Richard Eden, p. 199.

Insessores.

the particular habits and general economy have been the most minutely studied. It sometimes makes its appearance in Louisiana as early as the 10th of March, and shows itself some weeks later in the northern states, varying not only with the latitude, but the temperature of each season. Its nest is described by Mr Audubon as being of the most delicate nature, the external parts formed of a light-gray lichen found on the branches of trees, or on decayed fence-rails, and so neatly arranged round the whole nest, as well as to some distance from the spot to which it is attached, as to seem part of the branch or stem. These little pieces of lichen, he and others allege, are glued together with the saliva of the bird; but whether this fact has been proved by observation, or is only a natural inference from the actual appearance of agglutination, we cannot say. The next coating, however, consists of a cottony substance, and the innermost of all of silky fibres obtained from various plants, and extremely soft and delicate. In this delightful little bed the female lays only two eggs, of an almost oval form, and colour of pure white.[1] Not more than ten days are required for hatching; the young are ready to fly in seven or eight days; they are fed or cherished by the parents for nearly another week; and Mr Audubon is of opinion that they are no sooner able to provide for themselves than they associate with other broods, and perform their migrations apart from the old birds, as he has sometimes observed twenty or thirty young humming-birds resorting to a group of trumpet-flowers when not a single adult male was to be seen.[2] The migration of birds, as Dr Richardson has well observed, has in all ages been an object of pleasing speculation to the philosopher; but in no instance does it appear more wonderful than when contemplated in relation to these tiny tribes. The lofty and sustained flight of the eagle and albatross seems only commensurate with their gigantic size, and the irresistible sweeping of their mighty pinions; "but how is our admiration of the ways of Providence increased, when we find that one of the least of its class, clothed in the most delicate and brilliant plumage, and apparently more fitted to flutter about in a conservatory than to brave the fury of the blast, should yield to few birds in the extent of its migrations."[3]

The only instance with which we are acquainted of a humming-bird having been brought alive to England, is that mentioned by Latham. A young gentleman, a few days before sailing from Jamaica, observed a female of *Trochilus mango* sitting on her eggs. He secured the bird, cut off the twig, and brought the whole on board his vessel. The mother was fed with honey and water, and during the voyage hatched two young ones, which surviving their parent, were landed in England and lived for some time in the possession of Lady Hammond, from whose mouth they readily sipped nectar. The longest survivor, however, died in about two months after its arrival. These frail creatures are in fact far too impatient of continuous cold to endure the climate of Britain during winter. We shall conclude by observing, that the species are very numerous, and, like the generality of extensive groups, have been of late partitioned into many minor genera by M. Lesson, and others who have devoted themselves to their consideration. The range of size, as well as of character, is considerable,—*Trochilus minimus*, which is no larger than an able-bodied bee, is the least of all the feathered race,—while *Trochilus gigas*, a "triton 'mong the minnows," is the largest of humming-birds, and almost equals the dimensions of a swallow.

In proceeding with our exposition of the tenuirostral tribes, we now approach the *Hoopoes*, in close approximation to which is placed the genus Fregilus of Cuvier, containing only a single European species, the *Corvus graculus*, or red-legged crow of British writers, which we have already briefly noticed as a *Pyrrhocorax*. It is in truth so nearly allied to the Alpine crow (*C. pyrrhocorax*), or *choucard des Alpes*, both in structure and habits, and is so often seen in company with that species, that wherever the one may be placed, the other should not be far distant. M. Temminck, indeed, places them in the same genus, although the bill of the red-legged bird (or Cornish chough) is longer than the head, more subulate and slender at the point, and without any notch. Cuvier regards the *Corvus affinis* of Latham, and another species from New Holland, as both belonging to the genus Fregilus.

Insessores.

The true hoopoes (genus Upupa) are all distinguished by a crest upon the head, composed of a double row of lengthened plumes, and capable of being raised at pleasure. The only European species (*U. epops*, Linn. Plate CCCXCIII. fig. 3) is a summer bird of passage on the Continent, where it travels northward even as far as Sweden. It never breeds in Britain, though it sometimes accidentally occurs there. We had one sent us a few years ago from the county of Fife. This bird is called *bubbola* by the Italians, most probably from its peculiar cry. It keeps itself concealed among the trees; but is constantly heard repeating the syllable *bu, bu, bu, bu, bu*, with such a strong sonorous voice, that it may be heard at a great distance. Its song properly so called is only uttered during the honey-moon. Although the hoopoe lives and builds in woods, it may be often seen, in search of insect food, in fields and pastures. The nest is generally placed either in the natural hollow of a tree, or in the deserted excavation of a woodpecker. It is composed outwardly of feathers, and is lined with the hair of cows and horses. The eggs are grayish white, finely spotted with brown. This bird is very common in Egypt. A nearly allied species (*U. Capensis*) is found at the Cape, and occurs also in the East Indies; but we presume M. Savi is in error when he says the genus is likewise known in America.

The genus Promerops of Brisson has also an elongated slender bill, finely pointed, laterally compressed, somewhat convex above, with the nostrils open and cleft longitudinally. The tail is very long and graduated, and the tongue is extensile and bifurcated, so that the species are able to absorb the nectarous juices of flowers. The title seems now restricted to the African species, of which the only one distinctly known is the Cape promerops (*P. Capensis*, *Merops caffer*, Gm.), of a grayish brown above, with a white throat, bordered by two dark lines, the breast reddish, the abdomen yellow. The tail is of great length during the completed plumage; but the long, ribbon-like feathers are often absent, which greatly alters the external character of the bird. (See Plate CCCXCIII. fig. 5.)

In the magnificent and somewhat disputed genus Epimachus, Cuv., the bill, though more robust in some of the species, resembles that of the two preceding genera; but the base, or region of the nostrils, is beset with short, rounded, scale-like feathers, after the manner of the birds of paradise, which they somewhat resemble, moreover, in the great extension of certain portions of their plumage. They are also native to the same countries. The *Epimachus magnificus* has the general plumage of a rich velvet black, the head and throat lustrous, with changing tints of green and blue. The tail is of ordinary length and structure, but the sides are singularly ornamented by long extended filamentous feathers. (See Plate CCCXCIII. fig. 7.) The female is much less adorned, being, according to M.

[1] Dr Richardson describes the eggs as of "a reddish-white colour, and obtuse at both ends."

[2] *Ornithological Biography*, vol. i. p. 251.

[3] *Fauna Boreali-Americana*, part ii. p. 323.

Insessores. Lesson, reddish above and gray oelow, streaked with brown. The *Epimachus superbus* is likewise of a velvet black, glossed in various parts with golden green and purple, the flank feathers greatly developed, and terminated by a brilliant edging. The tail is of such enormous length (Plate CCCXCIII. fig. 4) that the total extent of this species is nearly four feet. The female (*Upupa fusca* of Gmelin ?) is described as reddish on the wings and tail, the body of a mingled black and brown. The two preceding kinds inhabit New Guinea. The *Paradisea alba* of the older systems is by some referred to our present genus, which has also been made to contain a beautiful New Holland species, known to the natives by the name of rifle-bird, and described by Mr Swainson under the title of *Ptilorus paradiseus*. It is the *Epim. regius* of Lesson and Garnot,[1] and was previously figured by Mr Wilson as *Epim. Brisbanii*, in honour of General Sir Thomas Brisbane, by whom it is believed to have been first transmitted to this country.[2] If not a true Epimachus, it certainly greatly resembles that genus, having the form and colouring of *E. magnificus*, and the same tendency (though less strongly developed) to an elongation of the lateral plumes. The obscure black and brown plumage of the female likewise corresponds to what M. Lesson regards as the sexual distinctions of the other species. We have had recent information, which confirms our former views, that it is not of honey-sucking propensities. It rather exhibits a tendency to scansorial habits; and in its search for insects its bill may be heard from some distance tapping the bark, like that of a woodpecker.

All the preceding groups of the Passerine Order belong to Cuvier's first primary division, which, as we said at starting (see page 567), is characterized by never having the outer united to the inner toe by more than the length of one or two phalanges.

Those which follow, on the contrary, forming the second and much less numerous primary division of our present order, have the outer toe almost as long as the middle one, and united to it as far as the base of the terminal articulation. Such a principle of division might, *a priori*, be inferred to lead to some serious mal-arrangement of the groups; for it is extremely unlikely that so trifling a character should be found in uniform accordance with other and more influential attributes, and the slightest study or most superficial inspection of this the *Syndactylous Division* of Baron Cuvier's passerine order will suffice to show that the said division is in many points extremely heterogeneous and unnatural. To prove this to the satisfaction of any one at all conversant with the character of the prevailing forms in Ornithology, it will suffice merely to enumerate its component parts, viz. the bee-eaters (*Merops*), the motmots (*Prionites*), the king-fishers (*Alcedo*), the todies (*Todus*), and the horn-bills (*Buceros*). It is indeed surprising that any one so gifted with the power of philosophical observation, so qualified by his profound acquaintance with comparative anatomy to trace the natural relations of living creatures, and so signally successful in his usual generalizations, should either have brought together, or permitted to remain in juxtaposition, so discordant a group. The regulating character supposed to be competent to amalgamate these discordant materials is alleged to consist simply in the close adherence of the outer and middle toe throughout a considerable portion of their length, that is, as far as the penultimate joints. Now, that this character by itself is of no avail in the formation of natural groups, is evident from two considerations:—1*st*, From its being found in numerous genera, which are admitted to bear no affinity to each other;—2*dly*, from its being absent in some of the component members of a natural family, and present in others. We may illustrate this by an example. In the South American genus *Ampelis* there are genuine species, in some of which the outer and middle toes are united, while in others they are free. This is well seen in the beautiful *Ampelis carnifex*, in which these parts are joined together, while in the closely allied species *A. pompadoura* they are disunited. Having called the reader's attention to this inconsistency, we shall proceed to a brief sketch of the different generic groups above named. Insessores.

In the beautiful genus Merops, Linn., the bill is elongated, somewhat triangular at the base, slightly arched, sharp pointed. The wings are long, and narrow at the extremity. The feet are short. The flight of these birds, commonly called bee-eaters, is easy and buoyant, resembling that of the swallow. The species are numerous in Africa and the East; but only one is accustomed to show itself in Europe, the *Merops apiaster*, or *common* bee-eater of English writers (to whom, however, it is one of the rarest of the feathered race), an elegantly-formed and richly-plumaged bird (Plate CCCXCIV. fig. 2). It arrives in the southern countries of the Continent in March, and departs in September. It flies in flocks, usually at a considerable elevation, and utters with hoarse and guttural voice, in startling disaccordance with its slender aspect, a continual cry of *gra, gra, gra*. It builds in deep horizontal holes in sandy banks, which it excavates in whole or in part, working vigorously with feet and bill, and kicking out the dry earth behind it with great dexterity. It lays six or seven eggs, white, lucid, and almost spherical. When the young are partly fledged, but not yet fit to fly, they creep to the mouth of their holes, where they seem to enjoy the happy summer light and genial sunshine; but on the least alarm they trundle stern foremost into their inner chambers, where they lie concealed until tranquillity again prevails. So accustomed do they seem indeed to this peculiar movement, that when taken from the nest, and placed in any more exposed position, they seek to escape by running backwards. In fact, for a time they seem unable to walk in any other direction. All these birds are exclusively insectivorous, and prey almost entirely on the hymenopterous tribes. Although they often take their food upon the wing, they also gather it from the ground; and whenever they espy the small hole which leads into the nest of wasp or bembex, they place themselves close beside it, and snap up the industrious tenants on their exit or arrival. The Italian contadini regard the cry of the bee-eater as a sign of rain when they hear it uttered from a great height. The appearance of this beautiful bird in England is accidental. We may add, that none of the species occurs in America.

In the genus Prionites, Illiger, the feet and form are similar, but the bill is much stronger than in the preceding, the margins of both mandibles are crenulated (see Plate CCCXCIV. fig. 3), and the tongue is feathered. These birds are natives of South America. The plumage of their head is loose, like that of our common jay, the tail is long and graduated, and in adult birds the two central feathers are often bare or barbless for a space not far from the extremity. They prey on insects, occasionally attack small birds, and build their nests in the hollows of trees. Example, the blue-crowned motmot, *Ramphastos momota*, Gmelin.

The genus Alcedo, containing the king-fishers, has the legs still shorter than the bee-eaters, and the bill long, straight, angular, and pointed (CCCXCIV. figs. 1 and 4). As originally constituted, it contained a numerous assemblage of species from various countries of the world, of shape

[1] *Voyage de Duperrey*, pl. xxviii.

[2] *Illustrations of Zoology*, vol. i. pl. xi.

Insessores.

and proportions rather awkward than elegant, but almost all remarkable for great splendour of plumage. The size and length of the bill are usually disproportioned to the body, and the feet and legs seem of a diminutive and apparently inconvenient form; but the shining silky lustre of the feathers, and their rich and infinitely varied hues of the most brilliant green and blue, contrasted with different shades of orange, black, and brown, render the genus one of the most showy and attractive within the entire range of the ornithological system. The *Alcedo ispida* (our common king-fisher) is the only species which occurs in Europe, and it yields to few of its brethren in its lustrous beauty. It is one of the rarest, and certainly the most highly adorned, of all our resident species. It haunts the banks of lakes and rivers, building in hollows near their margin, and preys chiefly on small fish, on which it darts with the rapidity of an arrow, plunging its little gem-like body for one flashing moment in the crystal stream.

Certain modifications observable in the form of the bill, and accompanied, as usual, by a corresponding change of habits, have induced the division of the original genus. For example, we owe to Dr Leach the formation of the genus Dacelo, of which the type is the giant king-fisher of New Holland (*A. gigantea* of Latham). The bill is very strong, curved at the extremity, and bulged beneath. These species (called *martin-chasseurs* by the French) inhabit forests, and build their nests, not in the excavated banks of rivers, but in the hollows of lofty trees; whereas the true king-fishers (*martin-pecheurs*) are never found at any distance from the "pure element of waters." The former also feed on insects rather than fish, and, the larger kind especially, are clothed in a dingier and less adorned plumage.

The one above alluded to (*D. gigantea*) is described by Mr Bennet as well known to the colonists of New South Wales by the name of laughing or feathered jackass,—a designation which occasioned a lady at home to declare, that of all the wonderful productions of Australia, she thought nothing could equal the "feathered donkey." Its peculiar gurgling laugh, commencing in a low and gradually rising to a louder tone, is often heard by travellers, proceeding from the branch of some lofty tree, where the bird is watching for its prey. It is said that one seldom laughs without being accompanied by another, apparently anxious to join in a duet. This bird is respected by Australian gardeners for destroying grubs, &c.; and Mr Bennet reports, that it also deserves protection on account of its devouring mice and venomous reptiles. "A gentleman told me he was perfectly aware of the bird destroying snakes, as he had often seen them carry the reptiles to a tree, and break their heads to pieces with their sharp, strong beaks." "One of these birds, seen upon the branch of a tree near a river, looking so stupid, and nodding as if asleep, was shot, and it was then found that this peculiar manner proceeded from its having swallowed a small snake, which had got into the stomach, throat, and bill, but had not yet accommodated itself in the former cavity."[1]

A rare and remarkable species, from the Moluccas, with a shorter bill than usual, and a much longer tail, sometimes called the ternate king-fisher (*A. dea*, Linn.), forms the genus Tanysiptera of Mr Vigors,—while a few small species which either want the inner toe, or possess it in a very rudimentary state, constitute the genus Ceyx of Lacepede. The latter occur in India. Example, *A. tribachys*, Shaw. (Plate CCCXCIV. figs. 5 and 11.)

The genus Todus contains some small American birds, supposed to resemble the king-fishers in their general form, their feet, and lengthened bills; but the latter organ is horizontally depressed, and obtuse at the extremity, the tarsi are more elevated, and the tail shorter. Their habits are insectivorous, and the species, very few in number as the group is now restricted, are by most Ornithologists arranged among the *Muscicapidæ*, near the genera *Platyrhynchus* and *Muscipeta*. The best-known, if not the only species, is the green tody (*T. viridis*, Linn.). It is found in the Antilles, and some of the equatorial regions of South America, where it hunts insects like a fly-catcher, but builds in holes in banks, after the manner of a king-fisher. Its nest is placed in a little chamber at the termination of a tortuous gallery, and both sexes are remarkable for their strong attachment to their young. This delightful bird is named ground-parrakeet by the Creoles of St Domingo. Though not very rare, it usually dwells in wild and solitary places, which is probably the reason of its being by no means frequent in the collections of Europe. The male utters an agreeable song during the pairing season, but at other times the green tody is a very silent bird. Its flight is straight and rapid, and it sits at times both on stones and trees. (Plate CCCXCIV. figs. 6, 7, and 9.)

Insessores

The genus Buceros, which includes the calaos or horn-bills, is the last of the great passerine order in the arrangement of Baron Cuvier (Plate CCCXCIV. figs. 8 and 10). It certainly differs greatly from those near which he makes it stand, nor does it amalgamate much better with its neighbours in more recent systems. The species are natives of Africa and India, and are characterized by their enormous bills, toothed along their edges, and frequently surmounted by an additional horny structure, which bestows on them a very striking and peculiar physiognomy. These excrescences vary considerably with the age of the individual, and are scarcely perceptible in the young birds. The horn-bills may be said to resemble the toucans in their heads, the crows in their general habits, and the syndactylous tribes in the form of their feet. Their tongue is very small. These birds may be regarded as omnivorous, as they feed indifferently on fruits, mice, small birds, reptiles, and even carcasses. They exhibit an awkward and uncommon aspect while in the act of flying, in consequence of the great size of their beaks and lengthened tails, and altogether their appearance is extremely uncouth. Perhaps one of the most singular features in their economy consists in their feeding greedily, and without injury, on the seeds of *nux vomica*.[2]

The African horn-bill (*B. Africanus*) is entirely black, and nearly as large as a turkey. The crowned species (*B. coronatus*) is a much smaller bird, scarcely equalling the size of a magpie. Le Vaillant saw a flock of more than five hundred of these birds, in company with crows and vultures, preying on the remains of slaughtered elephants. It is figured by Mr Swainson in the third volume of the first series of his beautiful Illustrations. A large and remarkable Indian species has been of late years described by Mr Hodgson. It measures four feet five inches from tip to tip of the wings, and is three feet six inches in length. Its body exceeds that of the largest raven, but is very lean and incompact. It is believed to feed chiefly on fruits, although it will seize upon reptiles when pressed by hunger. Its freedom from any offensive smell, and the excellence of its flesh, which is much esteemed as an article of food, go far to prove that its habits are chiefly frugivorous. In a domestic state it will eat meat either raw or dressed. Mr Hodgson's specimen, however, was fed mostly on boiled rice, mixed with ghee, and made into large balls. It was never observed to take any water. Whenever it swallowed a mouthful which on second thoughts it considered as somewhat too large, it imme-

[1] *Wanderings in New South Wales*, i. 222.

[2] *Edinburgh Cabinet Library*, British India, iii. 90.

Scansores. diately disgorged it for the sake of a little additional mastication.[1]

Order III.—SCANSORES or CLIMBERS.

This somewhat heterogeneous group, continued by Baron Cuvier as a separate order, forms, in the systems of our own more recent writers, merely an additional tribe in the primary division of the passerine or insessorial order. As the zoological treatises in our present work have been hitherto made conformable to the general principles which regulate the arrangement proposed by the great French anatomist, we shall not here swerve from our previous practice, although we doubt not, that among some recent alterations for the worse, there may also be found not a few for the better. We fear, however, that it may be some time before the Scansores, even of the modern systems, can be regarded as composed of very closely allied groups,—at least so long as people feel averse to see any natural connection between a creeper and a cockatoo. Be this as it may, our present order is composed of species the great majority of which possess two toes before and two behind; that is, one of the three anterior toes commonly so called, is either reversible at pleasure, or is permanently thrown backwards, so as to give great power and tenacity of grasp during their infinitely varied movements over the rugged bark or smoother branches of the forest trees, on which they chiefly dwell. By this peculiar structure many species are enabled not only to ascend with ease a perpendicular trunk, but to suspend themselves from the lower surface of a branch while searching for their favourite food, which consists of fruits or insects, according to the form of the bill, so greatly diversified in the scansorial order. In the parrot tribe the foot is also used in the conveyance of food to the mouth, and generally as a prehensile organ of a very perfect kind.

We are aware that more than one excellent Ornithologist has objected to the title of this order, as incapable of being strictly applied to the whole of the genera of which it is composed. It is no doubt true that many of the species (such as the cuckoo), in which the toes are in pairs, or yoke-footed, cannot climb, while it is equally evident that several other species (such as the creeper, *C. familiaris*, the already alluded to very distant connection of the cockatoo) are excluded from this order by reason of the structure of their feet, in spite of which, however, they contrive to climb unceasingly; and that under these circumstances the denomination cannot be rigorously applied as alike characteristic of what it contains, and as correctly exclusive of what it does not contain. But we believe the same objection may be made to apply at least with equal force to various parts of every other system yet proposed. The ordinal characters, considered in their totality, are seldom so natural, yet extended, as to admit of no exception; and it is extremely questionable whether a title should be immediately changed upon the discovery of every species which may not coincide with its most rigorous interpretation. In truth, this could not in many cases be effected merely on the consideration of a single character, without producing greater inconveniences than those which it is desired to obviate. Among scansorial birds, for example, we have several species with only three toes, and which it would therefore be unreasonable to expect should conform to the ordinal character of having two toes before and two behind. But in spite of that partial deficiency, they are, in every essential particular, "true to their order."

The bill in the scansorial tribes varies so greatly in the different genera, from the straight, lengthened, angular mandibles of the woodpeckers, to the deep, curved, compressed organ of the parrots, that we must omit all consideration of it in the ordinal characters, although the study of its form is essential in relation to the minor divisions. The species of this order are, with few exceptions, inhabitants of the forests, and usually build their nests in the hollows of ancient trees. Their powers of flight are not remarkable. The European genera are almost entirely insectivorous; the parrot tribe feed on fruits; the toucans exhibit a tendency to the carnivorous habits of the accipitrine tribes; while other genera sensibly enjoy a mingled or miscellaneous diet.[2] Scansores.

The genus Galbula, Brisson, has a straight, elongated, sharp-pointed bill, with the upper edge rather sharp; the legs are very short, and the anterior toes much united (Plate CCCXCV. fig. 1). The plumage of these birds, usually known under the name of *Jacamars*, is remarkable for its metallic lustre. The species inhabit South America, where they occur among trees in moist and marshy places. Examples, *G. paradisea* and *viridis*, Lath. They generally sit, according to Mr Swainson, on low naked branches in the forest paths, from whence they dart upon butterflies, spearing them with their long bills; and their haunts, indeed, may be frequently discovered by the ground being strewed with the beautiful wings of their mangled victims, the bodies of which they alone devour.[3] "A bird called jacamar," says Waterton, "is often taken for a king-fisher, but it has no relationship to that tribe; it frequently sits in the trees over the water, and as its beak bears some resemblance to that of the king-fisher, this may probably account for its being taken for one; it feeds entirely upon insects; it sits on a branch in motionless expectation, and as soon as a fly, butterfly, or moth passes by, it darts at it, and returns to the branch it had first left. It seems an indolent, sedentary bird, shunning the society of all others in the forest. It never visits the plantations, but is found at all times of the year in the woods. There are four species of jacamar in Demerara; they are all beautiful; the largest, rich and superb in the extreme. Its plumage is of so fine a changing blue and golden green, that it may be ranked with the choicest of the humming-birds. Nature has denied it a song, but given it a costly garment in lieu of it. The smallest species of jacamar is very common in the dry savannas. The second size, all golden green on the back, must be looked for in the Wallaba forest. The third is found throughout the whole extent of these wilds; and the fourth, which is the largest, frequents the interior, where you begin to perceive stones in the ground."[4] An Indian species (M. Lesson, however, assigns it to Cayenne), of which the bill is shorter, thicker, and somewhat arched, forms the genus Jacamerops of Le Vaillant (see Plate CCCXCV. fig. 2); and another from South America, with only three toes (*G. tridactyla*, Vieil.), constitutes the genus Jacamar-alcyon (Plate CCCXCV. fig. 3). These names, however unmusically composed, point out the natural relationship of our present group to the bee-eaters and king-fishers, with which (as *fissirostral* birds) they are combined in some modern systems.

The genus Picus, Linn., contains the well-marked, numerous, and extensively distributed tribe of woodpeckers, which occur in all the great divisions of the earth, with the exception of New Holland. The vast and solitary forests of North and South America are, however, their chief dominion, the greatest number, both there and in the old world, being found within the tropics. The bill is rather long, straight, angular, somewhat compressed or wedge-

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[1] *Transactions of the Physical Class of the Asiatic Society of Bengal*, part i. p. 178.
[2] Wilson's *Illustrations of Zoology*, vol. i. art. Scansores.
[3] *Nat. Hist. and Class. of Birds*, ii. 154.
[4] *Wanderings*, p. 137.

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shaped at the extremity, and admirably fitted for splitting the bark or excavating the decayed portions of trees. The tongue is long, and capable of great protrusion, in consequence of its muscular basis, and the length of the horns of the *os hyoides*. It is not only furnished with little spines pointing backwards, but is covered by a glutinous moisture secreted by the salivary glands, which aids in the capture of the smaller insects, the larger, it is said, being usually transfixed by the point itself. The tail-feathers are very stiff and elastic, and greatly aid the motion of the feet in climbing, being pressed upon the bark, so as in some measure to support the body. Woodpeckers are shy and solitary birds. During the breeding season they dwell in pairs, and are only met with in small family flocks throughout the autumn. With the exception of the parrots, they form the most extensive group among scansorial tribes, between one and two hundred species being known to naturalists. We have only four in Britain, viz. the green woodpecker (*P. viridis*), our most common species; the great black woodpecker (*P. martius*), which is a much rarer bird; the great spotted woodpecker (*P. major*); and the lesser spotted kind (*P. minor*). Besides these, several others occur on the continent of Europe.

In whatever clime or country woodpeckers are found, they are characterized by strong affinities of form and colour, and constitute a very natural group, although some slight modifications of the bill have given rise in recent times to the formation of a few subgenera.

Buffon has drawn a melting picture of the miseries of a woodpecker's life. According to the views of the always eloquent, but frequently erroneous and sometimes inconsistent Frenchman, no bird which earns its subsistence by spoil leads a life of such painful and uninterrupted labour. Nature appears to have condemned it to incessant toil,—for while other species freely employ their courage or address, and either glide along on fearless rapid wings, or lurk insidiously in closer ambush, the woodpecker is constrained to drag on a miserable existence in boring through the scaly bark and tough unyielding fibres of the hardest trees. Necessity admits no intermission of its labours,—no interval of sweet repose. Not even the darkness of the night, nor sleep, that "soft restorer," who throws her balmy mantle over such a mass of human misery, brings any solace here,—for the nocturnal hours are spent in the same constrained and painful posture as are those of day. It never shares in the joyous sports of the other inhabitants of the woods, and so far from joining in their glad responses, it rather deepens the natural sadness of the forest glades by its wild and melancholy cries. Now, what is all this but the most fantastic coinage of the brain?—as if the blessed beings which people this gladsome world endured the primal curse, and shared the self-inflicted ruin of our race! as if their joyful hearts were ever pressed by sorrow, or responded in wailing sadness to the woes of man! Spirit of Eblis! not yet has thy malign influence so encroached upon the "Benigner Power." Is there any thing on earth for which we may not cry alas! saving only the omnipotent goodness of God, who careth "for all his creatures,"—and amid the unmeasured wretchedness which springs from human folly, the wan faces of our fellow-men pent up in close-built cities, the drunkard's hollow eyes, his shaking limbs, and tattered garments (and all the horrid ills that vice is heir to), what is more inspiring than to see even a fragment of the face of nature,—some little open plot of garden ground, where in spring the blackbird still may sing his evening hymn, or the autumnal red-breast cheerily announce approaching winter? Is there sorrow there or suffering, save what may spring from some dark spirit in the mind of man, the "immortal rebel?" When Buffon himself, a great interpreter of nature, in spite of all his fitful fancies, yielded up his life to God who gave it, did the lilied fields of France reflect the sun's warm rays less brightly, or her sylvan choristers welcome with sadder note the rosy day-break of the ensuing morn; or when that more wretched hour arrived (which the hoary but irreverent parent was saved the pain to see) when his son's fair locks, dishevelled but not dishonoured, were streaming on the blood-stained floor of that insatiate scaffold, what cared the gladsome birds in field or tree? It would indeed be but a doleful thought, if misery such as man so often meets with among human kind, and which he is therefore prone to picture, were to spread itself from his own sad bosom into the depth of darkly shaded forests, where so many gorgeous feathered inmates dwell, or among ocean rocks amid upheaving waters, or wave-worn caves, or crystal rivers with their golden sands.

Scansores.

Let those who dwell with pity on the fate of our condemned bird go with us to America, and listen to the high-toned note of *Picus principalis* (the name itself might "threaten and command"), echoing from the giant trunk or moss-grown arm of some colossal tree, or watch his varied movements, while from gnarled stems he drives off impetuously broad flakes of flashing bark, which so accumulate around the base of pine or cypress, as if a human carpenter had there set up his habitation. Or if we cannot go to America, let us read a great observer's history of another species. "No sooner," says Audubon, "has spring called them (the golden-winged woodpeckers) to the pleasant duty of making love, than their voice, which by the way is not at all disagreeable to the ear of man, is heard from the tops of high decayed trees, proclaiming with delight the opening of the welcome season. Their note at this period is merriment itself, as it imitates a prolonged and jovial laugh, heard at a considerable distance. Several males pursue a female, reach her, and to prove the force and truth of their love, bow their heads, spread their tails, and move sideways, backwards and forwards, performing such antics as might induce any one witnessing them, if not of a most morose temper, to join his laugh to theirs. The female flies to another tree, where she is constantly followed by one, two, or even half a dozen of these gay suitors, and where again the same ceremonies are gone through. No fightings occur, no jealousies exist among these beaux, until a marked preference is shown to some individual; when the rejected proceed in search of another female. In this manner all the golden-winged woodpeckers are soon happily mated. Each pair immediately proceed to excavate the trunk of a tree, and finish a hole in it sufficient to contain themselves and their young. They both work with great industry and apparent pleasure. Should the male, for instance, be employed, the female is close to him, and congratulates him on the removal of every chip which his bill sends through the air. While he rests he appears to be speaking to her on the most tender subjects, and when fatigued is at once assisted by her. In this manner, by the alternate exertions of each, the hole is dug and finished. They caress each other on the branches, climb about and around the tree with apparent delight, rattle with their bill against the tops of the dead branches, chase all their cousins the red-heads, defy the purple-grakles to enter their nest, feed plentifully on ants, beetles, and larvæ, cackling at intervals, and ere two weeks have elapsed, the female lays either four or six eggs, the whiteness or transparency of which are doubtless the delight of her heart. If to raise a numerous progeny may contribute to happiness, these woodpeckers may be happy enough, for they have two broods each season. Even in confinement the golden-winged woodpecker never suffers its naturally lively spirit to droop. It feeds well, and by way of amusement will contrive to destroy as much furniture in a day as can well be mended by a different kind of workman in two. Therefore, kind reader, do not any longer believe that woodpeckers, I mean those of

Scansores. America, are such stupid, forlorn, dejected, and unprovided-for beings, as they have hitherto been represented."[1]

The other species to which we have above alluded is the beautiful ivory-billed woodpecker (*Picus principalis*, Linn.), of which the broad extent of dark and glossy plumage, with the well-defined snowy markings of the neck and wings, relieved by the rich tracery of the carmine crest, and brilliant yellow eye, in some way so reminded the enthusiastic Audubon of the noble productions of a great Flemish painter, that whenever he saw one of these gorgeous birds flying from tree to tree, he would exclaim, "There goes a Vandyke." The ivory-billed woodpecker confines its rambles to a comparatively small portion of the United States, and is never observed in the middle portions of the Union, where the nature of the wood does not appear to suit its habits. "Descending the Ohio," says Mr Audubon, "we meet with this splendid bird for the first time near the confluence of that beautiful river and the Mississippi; after which, following the windings of the latter, either downwards towards the sea, or upwards in the direction of the Missouri, we frequently observe it. On the Atlantic coast, North Carolina may be taken as the limits of its distribution, although now and then an individual of the species may be accidentally seen in Maryland. To the westward of the Mississippi, it is found in all the dense forests bordering the streams which empty their waters into that majestic river from the declivities of the Rocky Mountains. The lower parts of the Carolinas, Georgia, Alabama, Louisiana, and Mississippi, are however the most favourite resorts of this bird, and in those states it constantly resides, breeds, and passes a life of peaceful enjoyment, finding a profusion of food in all the deep, dark, and gloomy swamps dispersed throughout them. I wish, kind reader, it were in my power to present to your mind's eye the favourite resort of the ivory-billed woodpecker. Would that I could describe the extent of those deep morasses, overshadowed by millions of dark gigantic cypresses, spreading their sturdy moss-covered branches, as if to admonish intruding man to pause and reflect on the many difficulties which he must encounter should he persist in venturing farther into their almost inaccessible recesses, extending for miles before him, where he would be interrupted by huge projecting branches, here and there the massy trunk of a fallen and decaying tree, and thousands of creeping and twining plants of numberless species! Would that I could represent to you the dangerous nature of the ground, its oozing, spongy, and miry disposition, although covered with a beautiful but treacherous carpeting, composed of the richest mosses, flags, and water-lilies, no sooner receiving the pressure of the foot than it yields, and endangers the very life of the adventurer, whilst here and there, as he approaches an opening, that proves merely a lake of black, muddy water, his ear is assailed by the dismal croaking of innumerable frogs, the hissing of serpents, or the bellowing of alligators! Would that I could give you an idea of the sultry pestiferous atmosphere, that nearly suffocates the intruder during the meridian heat of our dogdays, in those gloomy and horrible swamps! But the attempt to picture these scenes would be vain. Nothing short of ocular demonstration can impress any adequate idea of them.

"The flight of this bird is graceful in the extreme, although seldom prolonged to more than a few hundred yards at a time, unless when it has to cross a large river, which it does in deep undulations, opening its wings at first to their full extent, and nearly closing them to renew the propelling impulse. The transit from one tree to another, even should the distance be as much as a hundred yards, is performed by a single sweep, and the bird appears as if merely swinging itself from the top of the one tree to that of the other, forming an elegantly curved line. At this moment all the beauty of the plumage is exhibited, and strikes the beholder with pleasure. It never utters any sound whilst on wing, unless during the love season; but at all other times, no sooner has this bird alighted, than its remarkable voice is heard, at almost every leap which it makes, whilst ascending against the upper parts of the trunk of a tree, or its highest branches. Its notes are clear, loud, and yet rather plaintive. They are heard at a considerable distance, perhaps half a mile, and resemble the false high note of a clarionet. They are usually repeated three times in succession, and may be represented by the monosyllable, *pait, pait, pait.* These are heard so frequently, as to induce me to say that the bird spends few minutes of the day without uttering them; and this circumstance leads to its destruction, which is aimed at, not because (as is supposed by some) this species is a destroyer of trees, but more because it is a beautiful bird, and its rich scalp, attached to the upper mandible, forms an ornament for the war-dress of most of our Indians, or for the short pouch of our squatters and hunters, by all of whom the bird is shot merely for that purpose. Scansores.

"Travellers of all nations are also fond of possessing the upper part of the head and the bill of the male; and I have frequently remarked, that on a steam-boat's reaching what we call a *wooding-place*, the *strangers* were very apt to pay a quarter of a dollar for two or three heads of this woodpecker. I have seen entire belts of Indian chiefs closely ornamented with the tufts and bills of this species, and have observed that a great value is frequently put upon them. The food of this species consists principally of beetles, larvæ, and large grubs. No sooner, however, are the grapes of our forests ripe, than they are eaten by the ivory-billed woodpecker with great avidity. I have seen this bird hang by its claws to the vines, in the position so often assumed by a tit-mouse, and, reaching downwards, help itself to a bunch of grapes with much apparent pleasure. Persimons are also sought for by them, as soon as the fruit becomes quite mellow, as are hag-berries. The ivory-bill is never seen attacking the corn, or the fruit of the orchards, although it is sometimes observed working upon and chipping off the bark from the belted trees of the newly-cleared plantations. It seldom comes near the ground, but prefers at all times the tops of the tallest trees. Should it, however, discover the half-standing broken shaft of a large dead and rotten tree, it attacks it in such a manner as nearly to demolish it in the course of a few days. I have seen the remains of some of these ancient monarchs of our forests so excavated, and that so singularly, that the tottering fragments of the trunk appeared to be merely supported by the great pile of chips by which its base was surrounded. The strength of this woodpecker is such that I have seen it detach pieces of bark seven or eight inches in length at a single blow of its powerful bill, and by beginning at the top branch of a dead tree, tear off the bark, to an extent of twenty or thirty feet, in the course of a few hours, leaping downwards with its body in an upward position, tossing its head to the right and left, or leaning it against the bark to ascertain the precise spot where the grubs were concealed, and immediately after renewing its blows with fresh vigour, all the while sounding its loud notes, as if highly delighted.

"When wounded and brought to the ground, the ivory-bill immediately makes for the nearest tree, and ascends it with great rapidity and perseverance, until it reaches the top branches, when it squats and hides, generally with

[1] *Ornithological Biography*, vol. i. p. 191.

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great effect. Whilst ascending, it moves spirally round the tree, utters its loud *pait, pait, pait*, at almost every hop, but becomes silent the moment it reaches a place where it conceives itself secure. They sometimes cling to the bark with their claws so firmly, as to remain cramped to the spot for several hours after death. When taken by the hand, which is rather a hazardous undertaking, they strike with great violence, and inflict very severe wounds with their bill as well as claws, which are extremely sharp and strong. On such occasions, this bird utters a mournful and very piteous cry."[1]

A few species in which the bill is obviously arched form the genus COLAPTES of Mr Swainson. They seem, moreover, distinguished by the broad, bright-coloured shafts of the quill-feathers. Such is the gold-winged woodpecker (*P. auratus*) already alluded to. These birds *perch* more frequently than the genuine woodpeckers, that is, grasp or encircle the smaller branches, and they also often feed upon the ground. A Brazilian species is even named *P. campestris*, from its habit of searching about in fields and plains for insects in the dung of cattle, or on ant-hills, where it finds an ample supply of favourite food. This form occurs also in Africa. Certain three-toed species were formed into the genus PICOIDES by Lacepede. (Plate CCCXCV. fig. 3.)

The genus YUNX of Linn., containing the wrynecks, remarkable for their beautifully brindled plumage, is of very limited extent. The sole European species (*Yunx torquilla*) is in Britain a rare but regular summer bird of passage, breeding in hollow trees, laying numerous eggs, and feeding on insects. The genus PICUMNUS of Temm. is nearly allied, but is distinguished by its extremely short tail. Example, *P. abnormis*, Temm. *Pl. Col.* 371, fig. 3, which comes from Java. *Picus minutus*, which some authors place here, is by others regarded as a *Yunx*.

In the genus CUCULUS of Linn. were originally placed a number of different insectivorous birds, commonly called cuckoos, which agreed in the general form of the feet, the lengthened tail, the bill of medium size, rather deeply cleft, somewhat compressed, and slightly curved. But they have since been formed into numerous minor groups, the most marked and conspicuous of which we shall here briefly notice.

The true cuckoos, genus CUCULUS, Cuv., have the bill of moderate strength, the tarsi short, and the tail of ten feathers. As an example, we name our common British species, *C. canorus*, so remarkable for its singular and somewhat anomalous habit of depositing its eggs in the nests of other birds, a fact now so well known, and so frequently recorded, that we need not here dilate upon the subject, however curious in itself. The nest of the hedge-sparrow (*Accentor modularis*) is that most usually chosen in the south of England,—that of the yellow-hammer (*Emb. citrinella*), the wagtail (*Mot. alba*), and the meadow titlark (*A. pratensis*), being, however, likewise devoted to the purpose. "In Northumberland," says Mr Selby, "constant experience tells me, that the nest of the last-mentioned bird is the one almost always chosen. Taking advantage of the absence of its dupe during the time of laying (which generally occupies four or five days), the cuckoo deposits its egg among the rest, abandoning it from that moment to the care of the foster-parent. As the same period of incubation is common to both birds, the eggs are hatched nearly together, which no sooner takes place than the young cuckoo proceeds instinctively to eject its young companions and any remaining eggs from the nest. To effect this object, it contrives to work itself under its burden (the back at this early age being provided with a peculiar depression between the shoulders), and shuffling backwards to the edge of the nest, by a jerk rids itself of the incumbrance; and this operation is repeated, till the whole being thrown over, it remains sole possessor. This particular tendency remains for about twelve days, after which the hollow space between the shoulders is filled up; and when prevented from accomplishing its purpose till the expiration of that time, as if conscious of inability, it suffers its companions to remain unmolested."[2]

Various supposed reasons have been assigned for this anomalous, and we might almost say unnatural, instinct. Some have attributed it to the displacement of certain viscera (the gizzard is said to be situate farther back than in most other birds), which unfits them for the purposes of incubation, while others imagine that the early period at which cuckoos migrate from this country (they are generally off by the beginning of July) makes it necessary that they should leave their offspring to the care of foster-parents.[3] But anatomical investigation has not proved any thing sufficiently peculiar in their structure to warrant the first conclusion; and as to the second, it seems to us not so much a deduction from a regulating and causative fact in their history, as the statement of an additional circumstance which renders that history still more singular, and which naturally leads to the question, not easily answered, of why do they migrate so early?[4] In short, we know nothing at all about the matter, further than that the cuckoo of Europe, like the cow-bunting of America, always lays eggs, but never hatches them. The same custom is alleged, we think upon a narrow and ill-considered generalization, to characterize the other kinds of cuckoo. It may be a practice common to several species, but the rare black and white spotted cuckoo (*Cuculus Pisanus*, Gm., an odd name for an African bird, which happened once upon a time to visit Tuscany) is stated by the authors of the *Storia degli Uccelli* to have *built a nest* in the woods of Pisa, and *reared four young ones*. This species is extremely rare in Europe. It is known, however, in the Genoese territory,[5] and the young have been occa-

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[1] *Ornithological Biography*, i. 341. [2] *British Ornithology*, vol. i. p. 398. [3] *British Ornithology*, vol. i. p. 399.

[4] Besides, in Italy and other southern parts of Europe, this migration does not take place till September, and yet the habits of the bird are precisely the same. "Quelli uccellini," says Savi, "nel covo de' quali il cuculo ha lasciato l'uovo, non vi fanno attenzione; come uno de' loro seguitano a covarlo, e quando è nato imboccano e custodiscono il piccolo cuculo, con lo stesso amore, e con la cura medesima de' figli propri. Ma ben presto egli paga d'ingratitudine le premure dell'amorosa sua balia: crescendo molto più de' compagni, dopo poco tempo il nido è per lui troppo stretto: allora ricorre a un barbaro espediente per procurarsi un alloggio più comodo:" &c...." Ripete quest' operazione successivamente, in ragione che cresce, e che gli altri compagni lo incomodano, di modo che alla fine rimane solo nel nido usurpato. Così quei miseri uccelli che construirono il nido e che han fatto da balia al cuculo, sono da lui privati ad uno ad uno di tutti i figli." Regarding the movements of the parent bird in Italy, he observes, "E uccello migratorio: arriva nell' Aprile, e parti in Settembre. Appena arriva comincia a cantare, e quantunque il suo verso non abbia alcuna varietà, non ostante la voce essendo dolce e rotonda, si sente con piacere. Grandissimo è il numero che ne rimane in Toscana: non vi è bosco in monte o in piano, che in primavera ed in estate, non risuoni dal *cu cu, cu cu*, di questo uccello. Nel Settembre comincia a muoversi per emigare: allora in alcuni anni se ne vede passare una quantità grandissima per la pianura Pisana. Nel Settembre del 1823, gli alberi dello stradone che da Pisa va al Parco Reale di S. Rossore, attraversando vastissime praterie, ne furono pieni per una diecina di giorni. Volavano i cuculi da una pianta all' altra, andavano a posarsi un poco sul prato, ritornavano sugli alberi, ma di là non si allontanavano, benchè continuamente fossero molestati dai non pochi cacciatori che vi erano acccorsi. Questi uccelli volano con grande agilità, e spesso, particularmente andando a posarsi, senza muovere le ali, come sogliono fare i Falchi." (*Ornitologia Toscana*, t. i. p. 152.)

[5] Calvi, *Catalogo d'Ornitologia di Genova*, p. 55.

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sionally killed in the south of France.[1] Many beautiful cuckoos are found in foreign countries.

Those of North America belong to the genus Coccyzus of Vieillot, and are distinguished by a greater length of tarsus. (Plate CCCXCV. fig. 4.) They seem to delight more in deep woody solitudes than the true cuckoos, the latter being often found on hilly pastures and open heathy ground, if fringed with wood. A stranger who visits the United States for the purpose of examining their natural productions, and passes through the woods in May or June, will sometimes hear, as he traverses the borders of deep, retired, high-timbered hollows, an uncouth guttural sound. He will frequently hear this without being able to discover the source from which it comes, as the yellow-billed cuckoo (*Coccyzus Americanus*) is both shy and solitary, and always seeks the thickest foliage for concealment. This bird is of a grayish brown, with bronzed reflections, beneath white, the inner vanes of the primaries reddish cinnamon colour, the lower mandible white, and the length from bill to tail about twelve inches. Considerable discussion has taken place among philologists regarding the native languages of North and South America,—remarkable, we are led to understand, for their great number and striking dissimilarity. We know not what may be the intention of the yellow-billed cuckoo in speaking as he does, or whether he is distinctly comprehended by his neighbours; but the following is Mr Nuttall's account of the elements of his conversation: "The male frequently betrays his snug retreat by his monotonous and guttural *kow kow kow kow*, or *koo koo koo koo*, and *ko kuk, ko kuk, koo koo koo kuk, koo ko koo, koo ko koo*, uttered rather plaintively, like the call of a dove. At other times the *kow kow kow kow*, and *'tk 'tk 'tk 'tk 'tak*, or *'kh 'kh 'kh 'kh 'kak, kow kow kow kow*, beginning slow, rises, and becomes so quick as almost to resemble the grating of a watchman's rattle, or else, commencing with this call, terminates in the distant cry of *kow kow kow*." From this peculiar iteration (Shakspeare would have called it "damnable," a word we sometimes hear in pulpits, but ourselves but seldom use), the species in question has received the name of *kow*-bird, and we do not wonder at it. It may be satisfactory to know, that the St Domingo cuckoo (*C. Dominicus*, Nut.) although it sometimes cries both *kow kow kow kow* and *'kh 'kh 'kh 'kh 'kh 'kak*, yet often utters, in a raucous guttural voice, especially preceding rain, a word which sounds like *orrattottoo* or *worrattottoo*, exactly which has not been yet determined.

In the genus Centropus of Illiger the bill is compressed and carinated, and the nail of one of the hind toes is long, straight, and pointed, like a lark's. The tail is greatly elongated. The species are native to India and Africa, where they build in hollow trees, and feed on locusts and other insects. Such are *Cuculus Ægyptius*, *Senegalensis*, *Bengalensis*, &c. The genus Leptosomus of Vieillot is constituted by the great Madagascar cuckoo (*C. cafer*, Lath.—*Lep. viridis*, Vieil.), the female of which, as described by Buffon, is according to M. Lesson a distinct species—*Lept. crombus*. These birds are said to be frugivorous. (Plate CCCXCV. fig. 5.)

In the genus Indicator, Vail., the bill is short, high, almost conical. (Plate CCCXCV. fig. 6.) The tail consists of twelve feathers, and is somewhat graduated, and at the same time a little forked. The skin is described to be so hard and tough as to resist the assaults of most hymenopterous insects; but bees, which they incessantly torment, are said to sting them in the eyes. The species, few in number, are known by the name of honey-guides, and inhabit Africa. The one mentioned by Sparrman is said to attract the notice of the Dutch and Hottentots by a shrill cry of *cher, cher;* and when it perceives itself observed, it flutters onwards to the hive of a wild bee, in hopes of partaking of the plundered honey. "I have had frequent opportunities," he observes, "of seeing this bird, and have been witness to the destruction of several republics of bees, by means of its treachery. I had, however, but two opportunities of shooting it, which I did, to the great indignation of my Hottentots." It may be here noticed, we hope without offence, that naturalists themselves seem not seldom to belong to that *irritabile genus*, of which poets are usually supposed to form the greater portion. Though Dr Sparrman asserts that he was a frequent eye-witness of the curious instinctive habits of the honey-guide, yet Vaillant doubts if that traveller ever saw the bird at all. He says that the account is merely a repetition of a fable believed and repeated by credulous people at the Cape, and that it is erroneous to suppose that the bird seeks to draw man after it for the purpose of sharing the plundered sweets, the fact being, that it calls not the man, but that the latter knows, by attending to the cry of the honey-guide while searching for its natural food, that he will be sure ere long to find the stores of the industrious insect. According to Bruce, the *moroc*, for so this singular species is sometimes named, occurs in Abyssinia; and he too throws discredit on Sparrman's statements,—his own being but ill received by not a few. However, Sir John Barrow, a careful and accurate inquirer, though not a professed naturalist, confirms it by stating that people in the interior of the South of Africa are too well acquainted with the moroc to have any doubts, either as to the bird itself, or its singular instinctive habits.

The *Barbacous* of Vaillant (genus Monasa, Vieil.) are South American birds, with rather conical elongated bills, slightly arched towards the tip, and furnished at the base with setaceous feathers. (Plate CCCXCV. fig. 7.) Such are *Cuc. tranquillus* and *tenebrosus* of the older systems, and the *Bucco albifrons* of Spix. We believe they are insectivorous. The *Malcohas* of Vaillant, again (genus Phœnicophæus, Vieil.), are Asiatic species, of which the most anciently known is native to Ceylon. (Plate CCCXCVI. fig. 1.) We here place the *Cuculus curvirostris* of Shaw, Latham's red-headed cuckoo, *C. pyrrhocephalus* of Forster, &c. and certain recent species described by Dr Horsfield and Sir Thomas Raffles. The preceding groups were all regarded as cuckoos by the older authors.[2]

The genus Scythrops of Latham, however, has a much stronger bill than any of these, marked by two slight longitudinal furrows. There is a naked space around the eye, and the nostrils are rounded. Only a single species is yet known, *Sc. Novæ Hollandiæ*, Lath., sometimes called the channel bill, a most peculiar looking bird, of the size of a crow, gray above, beneath dingy white. (Plate CCCXCVI. fig. 2.) In its bill it almost assimilates to the toucans, but its tongue is simple. Though it is mentioned both by White and Phillips, we know as yet but little of its habits. It occurs in New Holland, where it is sometimes seen in small flocks, but more usually in pairs, frequenting trees, and uttering during flight a loud and screaming cry, not unlike the crowing of a cock. Its food is said to consist both of fruits and insects. It also occurs in the Celebes, where its voice presages rain.

The genus Bucco of Linn., is characterized by a thickish conical beak, bulged laterally from the base, and furnished with five fasciculi of barbs directed forwards. The wings

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[1] Roux, *Ornithologie Provençale*, p. 105.

[2] For the various modifications of form exhibited by the Cuculidæ, and the numerous minor groups which have thence resulted, see M. Lesson's *Traité d'Ornithologie*, and a recent paper by Mr Swainson in the *Magazine of Zoology and Botany*.

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are short, and the flight heavy. The species feed on fruits and insects, and occasionally attack small birds. They build their nests in hollow trees. Cuvier divides them into three minor groups. The *Barbicans* of Buffon (POGONIAS, Illiger) have one or two strong teeth on each side of the upper bill, of which the ridge is arched and blunt. The barbs are very strong. (Plate CCCXCVI. fig. 3.) The species occur in Africa and India, and are more frugivorous than their congeners. Example, *P. sulcirostris*, Leach, *Zool. Misc.* xi. 76. The Barbus (genus BUCCO, as restricted) have the bill simply conic, slightly compressed, the culmen blunt, and a little raised about the centre. The species live in pairs during the breeding season, and in small flocks at other times. They occur in both continents, and are adorned with lively colours,—*Bucco grandis*, *viridis*, *flavifrons*, &c. Lastly, the *Tamatias*, genus TAMATIA, Cuv., have the bill more elongated and compressed, with the extremity of the upper mandible curved downwards. Their thick heads, large bills, and short tails, give them a stupid aspect. They inhabit South America, feed on insects, and are of solitary habits. Example, *T. melanoleucos*, *melanotis*, &c. They are known by the English name of *puff-birds;* and Mr Swainson describes them as sitting for hours together on a dead or withered branch, from which they dart from time to time on such unwary insects as approach within their reach. He adds, that the hermit-birds (genus *Monasa*), already mentioned, do the same, and frequently rise up perpendicularly into the air, making a swoop, and returning again to their former station. Similar manners belong to the jacamars, though their flight is weaker.

In the genus TROGON the bill is also bearded, but short, and broader than high, the upper edge rounded. Their little feet are often feathered almost to the toes, and their soft, full, lax plumage, and lengthened tails, bestow upon the species a peculiar aspect. (Plate CCCXCVI. fig. 4.) These birds abound in South America, where they conceal themselves in the central solitudes of umbrageous forests, and, except during the breeding season, dwell insulated and alone. They will sit motionless for half a summer's day, often upon a withered branch, and if not concealed by some accidental intervening mass of foliage, they fall an easy prey to the keen-eyed hunter, who eagerly searches for birds not less remarkable for the delicacy of their flesh than the beauty of their plumage. During the morning and evening hours, Mr Swainson informs us, they become more active; venturing at these times into the open parts of the forest, and, taking a shady station, dart upon winged insects, particularly beetles. At other times they feed upon fruits, especially the rich purple berries of the different melastomæ, "at which," says Mr Swainson, "they invariably dart, precisely as if they were insects capable of getting away." It has been remarked by the woodland hunters, that the skins of these birds are of such delicate texture as to be with difficulty preserved in a natural or complete condition. It is probably for this reason that in museums they exhibit a heavy, shapeless aspect, redeemed, it is true, by the gorgeous colours or metallic splendour of their plumage. The most magnificent of the genus is the quezal or golden trogon (*T. pavoninus*, Temm.), a rare and remarkable species, of which neither delineation nor description can convey an adequate idea. The greater proportion of the plumage is apparently composed of burnished gold. The head ornamented by a brilliant crest of decomposed barbs, the wing-coverts falling in flakes of golden green over the deep purplish-black of the primary and secondary quill-feathers, the rich carmine of the lower parts bestowing a warmth and depth of effect which no Venetian painter ever equalled, and the long waving and highly metallic feathers of the tail-coverts, extending about three times the length of the whole body, present a combination of beauty almost unexampled in the feathered tribes. The first specimens seen in this country were brought, we believe, by Mr Schenley from Vera Paez, in central America. They are celebrated in the Mexican mythology, and are much sought after as head-gear by the Peruvian damsels. Trogons, of other kinds, occur also in the Indian islands, and the warmer continental regions of the old world.[1]

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The genus CROTOPHAGA, Linn., is recognised by its thick, compressed, arched bill, without dentation, elevated, or surmounted by a vertical cutting crest. (Plate CCCXCVI. fig. 5.) The species called *anis* or keel-birds inhabit South America and the West Indies. They are of a familiar and gentle disposition in confinement, easily tamed, and may be taught to speak. Their plumage is black, with metallic reflections. They build in bushes (some say upon the ground), and several pairs will lay and hatch together in the same nest, which is made of size proportioned to the partnership. They feed on insects, keep much upon the ground, where they also attack maize and rice. M. Lesson says that *C. major* dwells more habitually on large trees, while *C. minor* prefers the savannahs and marshy meadows. Mr Swainson never saw the common ani perch on any thing higher than a bush.

The genus RAMPHASTOS, Linn., is distinguished by its enormous bill, which in some instances is almost equal in size to the body. It is, however, extremely light, and cellular within, arched towards the extremity, and irregularly toothed along the margins. The tongue is long, narrow, and barbed on each side, like a feather. These birds, commonly called toucans, inhabit South America, where they live habitually in woods, and prey on fruits, eggs, and new-hatched birds. The species are pretty numerous, and almost all distinguished by brilliant colouring, which however is somewhat too strongly contrasted, and consequently deficient in that fine gradation or harmonious blending which beautifies less gorgeous tribes. We have never chanced to see them in the living state, but in museums they present a somewhat awkward aspect, from their disproportioned bills, short feet, and lengthened tails. Their sense of smell is said to be extremely acute,—a faculty by some attributed to an extended ramification of nerves within the nasal portion of the bill. The genus is now divided into two: 1*st*, The toucans proper (genus RAMPHASTOS, Plate CCCXCVI. fig. 6), which have the largest bills, with the ground colour of the plumage usually black, the throat, breast, and rump being more gaily ornamented with white, yellow, and red. 2*dly*, The aracaris (genus PTEROGLOSSUS, Illiger, Plate CCCXCVI. fig. 7), in which the bill is smaller than the head, and the ground colour of the plumage generally green, with red or yellow on the throat and breast. A live specimen of *Ramphastos tucanus*, of which the manners have been described by Mr Vigors, was extremely fond of fruit, both fresh and dried. These it generally held for a short time in the extremity of the bill, touching them with apparent delight with its slender feathered tongue, and then tossing them into its throat by a sudden upward jerk. Its tendency to prey on animals was, however, strongly evinced by the excitement produced by the sight of a living bird; and the carnivorous propensities of another individual are curiously related by Mr Broderip. A goldfinch (though, we repeat, we approve not of the fact), introduced into the toucan's cage, was seized and compressed so suddenly, that the poor little songster had only time to utter a short squeak before it was dead, with its bowels protruding. The toucan then hopped with it to

[1] Mr Gould has published a *Monograph of the Trogonidæ*, with sumptuous coloured plates.

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another perch, and began to strip off its feathers. When it was nearly naked, it broke the bones of the wings and legs, taking them in its bill, and giving them a strong lateral wrench. Having reduced the little victim to a shapeless mass, it first swallowed the viscera, and then the remaining parts, piece after piece, not even rejecting the legs and bill. Mr Broderip adds, that he has sometimes observed it return its food from its crop, and swallow it again, after a second mastication.

The genus PSITTACUS, Linn., comprehending the almost innumerable tribe of parrots, lories, parrakeets, maccaws, and cockatoos, has the bill thick, hard, solid, rather short, rounded on all its outlines, deep, curved, and generally sharp-pointed. The tongue is almost always thick, round, and fleshy, and the lower larynx furnished on each side with three peculiar muscles, which probably contribute to the great facility with which these birds acquire the articulate intonation of the human voice. Their strong and powerful jaws are brought into action by muscles more numerous than usual. Their natural food consists of fruits and seeds. They climb trees with the greatest facility, and suspend themselves indifferently from feet or bill. Their voices are harsh and discordant, their forms often elegant, their plumage usually of great richness. They form indeed a magnificent family, abundant in almost every region of the torrid zone, and in the new world extending from the shores of the Ohio to the Straits of Magellan,—thus presenting a vast and varied assemblage of species from every country of the world, excepting the comparatively cold and cloudy clime of Europe. The gorgeous maccaws are characteristic of South America, the cockatoos of New Holland and the Asiatic islands, the lories of the East Indies and the Moluccas; whilst several groups of parrots, parrakeets, &c. are widely distributed over various regions of the earth. Above two hundred different kinds are known to naturalists.

It was the opinion of Buffon that none of the parrot tribe extended either northwards or southwards beyond the twenty-fifth degree, on either side of the equator. Having apparently resolved, *a priori*, on these lines of circumvallation, he despised, as Pennant observed, the authority of the Dutch navigator Spilbergen, who was eye-witness to the woods of Terra del Fuego, the very southern boundary of the Straits of Magellan, in south latitude 44°, being full of them. He might also have cited the evidence of Captain Hood, who saw a parrot at Port Famine; and of Commodore Byron, who notwithstanding the coldness of the climate observed parrots innumerable in the woods of that same harbour. They were found by Captain Cook in New Zealand, by Captain Furneaux at Van Diemen's Land, and by the learned Forster in the raw wet climate of Dusky Bay. The emerald parrot, *Psit. smaragdinus*, Gmel., was lately seen in great numbers by Captain King, among thick underwood, in the Straits of Magellan, south latitude $53\frac{1}{2}°$; and others are well known to occur in Macquarrie Island, which lies in latitude $54\frac{1}{4}°$ south. A species inhabits North America, extending even beyond the Illinois River to the neighbourhood of Lake Michigan, in the forty-second degree of north latitude. It was seen by Alexander Wilson in the month of February, flying in flocks along the banks of the Ohio, during a storm of snow, and yet in full rejoicing cry. These, and many similar facts, are now well known to naturalists.

The modern subdivisions of this great natural family are too numerous and minute to be here recorded.[1] We must therefore satisfy ourselves with a brief indication of the principal groups. We presume nobody at this time of day, under the pretence of *popular* reading, desires to be edified by anecdotes of parrots, so we shall devote the little space we can afford for miscellaneous matters, to a few notices of some of the species which have bred in Europe. Of these we may here mention, as the principal, the great blue and buff maccaw (*P. ararauna*); the gray parrot (*P. erythacus*); the sinciale, ring-necked, and pavouan parrakeets (*P. sincialo, torquatus, Guianensis*); and the black-capped or Philippine lory (*P. tricolor*). The general belief is that the parrot tribe will not breed in Europe; but knowing several instances to the contrary, we wish to impress upon the public the probability that many more would occur were the experiment tried with frequency and judgment.

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The gorgeous maccaws form the genus MACROCERCUS of Vieillot. The face is either naked, or merely striped with feathery lines. The tail is very long, wedge-shaped, and sharp-pointed. (Plate CCCXCVII. fig. 1.) These birds, the largest and most magnificent of the parrot tribe, inhabit South America. The great scarlet maccaw (*Psittacus aracanga*, Lath.), when in perfect plumage, sometimes measures above three feet in length, the tail of course included. The prevailing plumage is scarlet, as its name implies, the wings blue, the wing-coverts varied with yellow, the cheeks white and wrinkled. It is certainly a sumptuous creature, but after all rather too like a richly liveried footman,—an association somewhat strengthened by its being so often seen as an inhabitant of lordly mansions, and surrounded by other menial bipeds, almost as gorgeous as itself. Our feelings would no doubt have been different had we ever witnessed their natural evolutions. "It is a grand sight in Ornithology," says Waterton, "to see thousands of aras flying over your head, low enough to let you have a full view of their flaming mantle." How delightful would it have been, on some bright and dewy morning, to have accompanied Lord Anson to view a magnificent rapid in the island of Quibo. A fine river of transparent water there precipitates itself along a rocky channel, forming numerous falls, and the great disrupted rocks which form its boundary on either side are crowned with lofty forest trees. "While the commodore and those who were with him attentively viewing the place, were remarking the different blendings of the waters, the rocks, and the woods, there came in sight as it were still more to heighten and animate the prospect, a prodigious flight of maccaws, which hovering over this spot, and often whirling and playing on the wing about it, afforded a most brilliant appearance by the glittering of the sun upon their varied plumage; so that some of the spectators cannot refrain from a kind of transport when they recount the complicated beauties which occurred at this extraordinary water-fall." The blue and yellow species (*P. ararauna*, Linn.) is little inferior to the preceding, either in size or sumptuousness. It is less common, and seems to have been first described by Aldrovandus, from a specimen which he saw in the palace of the Duke of Mantua. It is said to be also less easily reclaimed as a domestic bird,—yet we have not seldom enjoyed the society of a very fine example which makes its way familiarly (such is its custom in the afternoon) amid the varied horticultural produce which graces the *dessert* of Dr Neill. Many other splendid species are described and figured in the works of naturalists.

In the genus ARATINGA of Spix, the bill is slender, dentated; the orbits of the eyes naked, the cheeks rarely so; the tail lengthened, wedge-shaped, the intermediate feathers prolonged. The species are peculiar to the new world. Such are *Ar. Carolinæ-Augustæ, chrysocephalus*, &c. To these the genus PSITTACARA of Vigors seems allied, the bill, however, being shorter and stouter, and

[1] The most complete and scientific treatises with which we are acquainted on the parrot tribe are,—*Conspectus Psittacorum*, ab H. Kuhl, Ph. Dr. &c. in *Nova Acta Acad. Nat. Cur.* tom. x. p. 1; and Wagler's *Monographia Psittacorum*.

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The genus PALÆORNIS of Vigors has the bill rather thick, the culmen of the upper mandible rounded, the lower broad, short, emarginate. The middle feathers of the tail are greatly lengthened. The most anciently known of the parrot race belong to this genus, such as the Alexandrine parrakeet, and other long-tailed species, distinguished by their elegance of form, their ruby-coloured bills, their semicircled necks, and the rich *verdure* of their plumage. The one just named is native to India and Ceylon, and derives its designation from the fact, real or supposed, of its having been first transported from Asiatic countries by Alexander the Great. Its most distinguishing characters consist in the broad black patch which occupies the fore-part of the throat, and extends laterally in two narrow processes on each side of the neck; a black line stretches from the base of the beak to the eyes, and there is a deep purplish-red patch at the base of the wings. Its bill is larger than that of the rose-coloured parrakeet (*P. torquatus*), which, however, it greatly resembles in its general aspect. The last-named species is widely spread over India, and as far eastward as Manilla. It appears, indeed, to be identical with another species extremely abundant on the African coasts, and well known in France under the title of *perruche de Senegal*. In so far as any conclusion can be drawn from the vague and brief descriptions handed down by ancient writers, it would appear that this species was, as it still continues to be, more frequent in the days of antiquity than any of its congeners. No allusion is made by these authors to those specific marks by which the Alexandrine parrakeet is so clearly distinguished, and the general description applies very closely to the rose-necked kind. That the latter was extensively known, and held in high esteem on account of the brilliancy of its plumage, the docility of its manners, and its successful imitative powers, is proved by innumerable passages in the classical writers of antiquity, more especially from the earliest times of the Roman empire, to a very late period of its annals.[1] The Alexandrine parrot is generally supposed to have been brought to Europe from the island of Ceylon, the ancient Taprobane. In the reign of Nero, the Romans introduced other species from different quarters of Africa.[2] They were highly prized by that luxurious people, who lodged them in superb cages of silver, ivory, and tortoise-shell; and the price of a parrot in those days frequently exceeded that of a slave.[3] Nor did Ovid think it beneath him to write a lengthened elegy on the death of Corinna's favourite,—a bird which, in the love it bore its mistress, seems to have emulated that of the dying Greek for his country :—

Clamavit moriens lingua, Corinna, Vale.[4]

In the same group is generally included that beautiful and richly varied species from the Molucca Islands, called the blue-bellied parrakeet, *Ps. cyanogaster*, Shaw. Its tongue, in common with that of several New Holland parrakeets, is finely ciliated at the tip on either side. Hence the formation in their favour of Mr Vigors's genus TRICHOGLOSSUS. Vailliant, during his residence at the Cape, had an opportunity of studying the manners of a pair of the species just named, which had been imported from Amboyna. They bred during their confinement in the menagerie of M. Van Bletemberg, then governor of the Cape. The female deplumed her beautiful breast, and after having collected the feathers into a heap, deposited two round white eggs, on which she sat most assiduously, the male feeding her at intervals, by disinterestedly disgorging what he had swallowed, and presenting the same to his spouse. The young were produced at the end of nineteen days, and in the space of a few more became covered with a gray cinereous down, which was by degrees succeeded by green feathers on the body, and by blue ones on the head. At the end of three weeks they left the nest, and perched upon the neighbouring sticks, where the male and female fed them in concert, as above described, after the manner of pigeons. The parent birds continued to tend them in this manner for six months, and often afforded a very interesting scene,—the young being frequently seated beyond the female, and the male not being able to *reach* them, first presented the food to his mate, who immediately delivered it to her young. These, though of different sexes, were perfectly alike till the first moulting, at which time red feathers bordered with green began to appear upon the breast, and the male became distinguished by the blue patch upon the abdomen.[5]

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In the genus PLATYCERCUS, Vigors, the tail is broad, depressed, and somewhat rounded. The species inhabit New Holland, and the islands of the South Pacific and Indian Oceans. Examples *Pl. Pennantii*, *Tabuensis*, &c.

Among the *perruches ordinaires* of Cuvier (a portion of the genus CONURUS, Kuhl), distinguished by a regularly graduated tail, without any disproportionate prolongation of the central feathers, we have the Carolina parrot of Wilson (*Ps. Carolinensis*, Linn.), a green plumaged bird, with yellow head and neck, the forehead and cheeks orange. Of more than two hundred species now known to belong to the parrot tribe, this is the only one which inhabits the United States, where it is chiefly restricted to the warmer portions,—venturing but rarely beyond Virginia. West of the Alleghanies, however, circumstances induce it to visit much higher latitudes,—so that, following the great valley of the Mississippi, it is seen to frequent the banks of the Illinois, and occasionally to approach the southern shores of Lake Michigan. Straggling parties have even been sometimes observed in the valley of the Juniata, in Pennsylvania; and a flock, to the great surprise of the Dutch inhabitants of Albany, are said to have appeared in that vicinity. This species constantly inhabits and breeds in the southern states, and is so far hardy as to make its appearance, commonly in the depth of winter, along the woody banks of the Ohio, the interior of Alabama, and the banks of the Mississippi and Missouri around St Louis and other places, when nearly all other southern birds have migrated

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[1] Ancient writers are unanimous in their statements that parrots came to us first of all from India. Aristotle calls the Psittacus "το Ινδικον ορνιον;" and Arrian also makes it a native of the East (*Hist. Ind.* cap. xv.). The parrots of Africa became first known to the Romans in the time of Nero. (Plin. *Nat. Hist.* lib. vi. c. 29.) For the classical history of these birds, see Mr Vigors's "Sketches in Ornithology,"—*Zoological Journal*, vol. ii. p. 37.

[2] See *Zoological Gardens*, vol. ii. p. 96.

[3] The splendour of a parrot's cage is thus described by Statius :—

At tibi quanta domus, rutila testudine fulgens,
Connexusque ebori virgarum argenteus ordo,
Argutumque tuo stridentia limina cornu,
Et querulæ jam sponte fores : vacat ille beatus
Carcer.—*Sylv.* lib. ii.

[4] *Edinburgh Cabinet Library*, Africa, p. 480.

[5] Shaw's *General Zoology*, vol. viii. p. 414.

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before the storms of that inclement season.[1] We may judge of the abundance of this species, even up to a recent period, from the statement of Vaillant, who assures us that he saw a package containing above 6000 skins, which had been sent to a *plumassier* at Paris, for the formation of ornamental dresses.[2] Mr Audubon, however, informs us that their numbers are now rapidly diminishing, and that in some districts where, twenty-five years ago, they were plentiful, scarcely one is to be seen. "I should think," he adds, "that along the Mississippi there is not now half the number that existed fifteen years ago." With a view to illustrate the natural habits of these birds, we extract the following account from the work of an English gentleman now settled in America. "The Carolina parrakeets in all their movements, which are uniformly gregarious, show a peculiar predilection for the alluvial, rich, and dark forests bordering the principal rivers and larger streams, in which the towering cypress[3] and gigantic sycamore[4] spread their vast summits, or stretch their innumerable arms, over a wide waste of moving or stagnant waters. From these, the beech, and the hack-berry,[5] they derive an important supply of food. The flocks, moving in the manner of wild pigeons, dart in swift and airy phalanx through the green boughs of the forest; screaming in a general concert, they wheel in wide and descending circles round the tall button-wood, and all alight in the same instant, their green lustre, like the fairy mantle, rendering them nearly invisible beneath the shady branches, where they sit, perhaps arranging their plumage, and, shuffling side by side, seem to caress and scratch each other's heads with all the fondness and unvarying friendship of affectionate doves. If the gun thin their ranks, they hover over the screaming, wounded, or dying, and returning and flying around the place where they miss their companions, in their sympathy seem to lose all idea of impending danger. More fortunate in their excursions, they next proceed to gratify the calls of hunger, and descend to the banks of the river or the neighbouring fields in quest of the inviting kernels of the cockle burr,[6] and probably of the bitter weed,[7] which they extract from their husks with great dexterity. In the depth of winter, when other resources begin to fail, they, in common with the yellow-bird and some other finches, assemble among the tall sycamores,[8] and, hanging from the extreme twigs, in the most airy and graceful postures, scatter around them a cloud of down from the pendant balls, in quest of the seeds which now afford them an ample repast. With that peculiar caprice, or perhaps appetite, which characterizes them, they are also observed to frequent the saline springs or *licks*, to gratify their uncommon taste for salt. Out of mere wantonness, they often frequent the orchards, and appear delighted with the fruitless frolic of plucking apples from the trees, and strewing them on the ground untasted. So common is this practice among them in Arkansas territory, that no apples are ever suffered to ripen. They are also fond of some sorts of berries, and particularly of mulberries, which they eat piecemeal in their usual manner, as they hold them by the foot. According to Audubon, they likewise attack the outstanding stacks of grain in flocks, committing great waste; and on these occasions, as well as the former, they are so bold or incautious as readily to become the prey of the sportsman in great numbers. Peculiarity of food appears wholly to influence the visits and residence of this bird, and in plain, champaign, or mountainous countries, they are wholly strangers, though common along the banks of all the intermediate water-courses and lagoons.

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"Of their manners at the interesting period of propagation and incubation we are not yet satisfactorily informed. They nest in hollow trees, and take little if any pains to provide more than a simple hollow in which to lay their eggs, like the woodpeckers. Several females deposit their eggs in the same cavity; the number laid by each is said to be only three, which are nearly round, and of a light-greenish white.[9] They are at all times particularly attached to the large sycamores, in the hollow trunks of which they roost in close community, and enter at the same aperture, into which they climb. They are said to cling close to the sides of the tree, holding fast by the claws and bill; and into these hollows they often retire during the day, either in very warm or inclement weather, to sleep or pass away the time in indolent and social security, like the *Rupicolas*[10] of the Peruvian caves, at length only hastily aroused to forage at the calls of hunger. Indeed, from the swiftness and celerity of their aërial movements, darting through the gleaming sunshine, like so many sylvan cherubs, decked in green and gold, it is obvious that their actions as well as their manners are not calculated for any long endurance, and, shy and retiring from all society but that to which they are inseparably wedded, they rove abroad with incessant activity, until their wants are gratified, when, hid from sight, they again relapse into that indolence which seems a relief to their exertions."[11]

The pavouan parrakeet (*Ps. Guianensis*, Lath.) belongs to our present group. This species is native to Cayenne, and the Antilles, where it is not uncommon, often flying about in flocks, frequenting the wooded savannahs, and feeding by preference on the berries of *Erythrina corallodendron*. Its length is about twelve inches, its prevailing plumage green, the cheeks and sides of the neck being speckled with bright red, which becomes more conspicuous as the bird advances in age; the smaller wing-coverts are bright red, the greater yellow, and both the quill and tail feathers are dusky yellow beneath. The bill is whitish, the legs and feet gray. We owe to M. Gabriac the following interesting particulars regarding the breeding of a pair of this species in the domestic state. Two cages were prepared for their reception in the month of April. They were placed contiguous, but communicating only by a small door, and the one enjoyed the "blessed light of day," while the other was kept covered, so that no light could enter but by the mutual door. The latter also contained an abundant supply of saw-dust. The birds were placed in the open apartment, which was the larger of the two, and they speedily showed symptoms of tender attachment to each other. They long declined, however, to enter the darkened dwelling, although the female put in her head, withdrew it again, advanced part of her body, then returned tail foremost,—but finally, after several days of hesitation, she entered the mysterious chamber. There she expressed her satisfaction by little kindly cheerful cries, and often called in the male, who exhibited every proof of affection. She soon began to scrape about, and arrange a kind of nest, and on the 18th of May she layed her first egg, succeeded at intervals of three days by a second, third, and fourth,—after which she sat assiduously. The male took no share in the hatching, but he kept constantly close by the nest, as if to cheer her sedentary hours. He did not however allow his affection to his wife to interfere with his duty to his hoped-for family. If the female, who never left the nest but to solace herself with meat and drink, appeared to devote too much time to that indulgence, he remanded her back by a little blow with his

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[1] Nuttall's *American Ornithology*, vol. i. p. 546.
[2] *Hist. Nat. des Perroquets.*
[3] *Cupressus disticha.*
[4] *Platanus occidentalis.*
[5] *Celtis occidentalis.* *Xanthium strumarium.*
[6] *Ambrosia, species.*
[7] *Platanus occidentalis.*
[8] Audubon, *Orn. Biog.* i. p. 139.
[9] *Cock of the rock* of Peru, which is also somewhat related, apparently, to the parrots. (Note by Mr Nuttall.)
[10] Nuttall's *Manual of Ornithology*, i. 456.

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beak, which occasionally produced something approaching to a quarrel. At the termination of twenty-five days, there being no appearance of progeny, the eggs were purposely withdrawn and broken, and were found to contain young in different stages of development, but all dead. This result was attributed to stormy weather, which had prevailed during incubation. Fortunately a second laying, accompanied by the same circumstances as the first, commenced on the 14th of July, and after twenty-three days, counted rigorously, the young appeared from each egg in a succession corresponding to the order of laying. They were at first covered by a grayish down, and were cherished with the tenderest solicitude by the parents, who on the approach of any threatened danger defended them with the greatest courage. It was in truth a curious sight to see two creatures before so kind and tenderly affectionate to those around them, so grateful for their food, and so solicitous of human kindness, converted by the strength of this new passion into little tigers, and so intractable as to attend no longer to fair hands or gentle voices. This natural wildness showed itself also strongly in the young ones, who recognised alone their parents, and bit and scratched at all the world besides.

A few species have the tail square, with the central feathers prolonged, and these in *Ps. setarius*, Temm. *Pl. Col.* 15, are bare of barbs, except at the tip.

The great mass of *parrots* properly so called, belonging to the restricted genus Psittacus, have the bill rather strong, the face clothed with feathers, the head large, without crest, the body thick, and the tail rather short and square. Green is the prevailing colour of the plumage, and the species are native to various countries both of the old world and the new. One of the best known, and most remarkable for its easy docility, the distinctness of its articulation, and general loquacious powers, is the common gray parrot, *Ps. erythacus*, of which the tail is red, and the orbits white and naked. It is an African species, and one of the earliest and most frequently imported. It has been known to breed in Europe,—a French gentleman at Marmande having had a pair which produced young ones for five or six years successively. They made their nest in spring, in a cask filled with saw-dust, the number of eggs being four, of which one was always unproductive. According to Labat a similar instance had previously occurred at Paris. Our present square-tailed group is very numerous.

The lories (genus Lorius, Vig.) have the bill rather attenuated, the upper mandible much arched, compressed, the lower lengthened, and nearly entire. The tongue is described as bristly and tubular. The tail is rather short, slightly graduated. Various shades of red form the prevailing colour of the plumage. The species inhabit the East Indies and the Asiatic islands. Example, *Ps. unicolor*, *garrulus*, &c.

Certain short-tailed species, of small size, which inhabit the tropical countries of both the new and old world, form the genus Psittaculus of Kuhl. Such are *Ps. passerinus*, *tui*, &c. They are erroneously called parrakeets by some of our English writers, a name which would confound them with the long-tailed species already alluded to, and more generally recognised under that title. The vast extent of the parrot tribe renders subdivision extremely desirable as a matter of convenience; but it must be confessed that a mere difference in size and colour is not of itself sufficient to authorize the separation of groups, or the formation of genera.

The genus Microglossus, Vieil., is, however, better founded. The bill, especially the upper mandible, is very large and strong, the head ornamented by a crest of narrow feathers, and the face naked. The tongue is cylindrical, lengthened, and tubular, capable of being greatly protruded from the mouth, and ending in a kind of corneous gland, cloven at the tip. (See Plate CCCXCVII. figs. 5 and 6.) The legs are more naked than usual, and the tarsi, on which they occasionally rest while walking, very short and square. The tail is square or even. We are not acquainted with more than two species, both from eastern countries. The black or giant cockatoo (*Ps. gigas*), called by old Edwards "a parrot of the first magnitude," and *Ps. aterrimus* of Gmelin, are the birds alluded to. Their synonymy seems confused. They inhabit New Guinea and the isle of Waigiou; and Edwards's figure was taken from a living specimen in Ceylon, but whether indigenous or imported does not appear. Vaillant observes of one of the species (his *ara noir à trompe*), that in cold weather it covered the bare space on each side of its face by lowering over them the feathers of the crest.

The great New Holland species, called the Banksian cockatoo, discovered in the course of Captain Cook's first circumnavigation, forms, with others, the modern genus *Calyptorhynchus*. (Plate CCCXCVII. fig. 2.) These large dark-coloured species are as yet but ill defined. They are said to live on roots; but Mr Bennet alludes to one which feeds on the larvæ of insects, as well as on the seeds of Banksia, Hakea, and even of Xanthorrhœa, or grass tree; and in the travels of that gentleman we find the following passage, which relates to a certain locality in New Holland. "Black and white cockatoos had lately become very numerous about this part of the country: the former appeared to have been attracted by some trees that had been felled when clearing a spot of land for cultivation,—as these birds visit the dead or fallen trees to procure the larvæ of insects that breed in them. I have seen, more than once, small trees lying prostrate, occasioned by the powerful bills of the large black cockatoos, who, observing on the trunk, externally, indications of a larva being within, have diligently laboured to extract it; and should the object of their search be situated (as often occurs) far in, before they reach it the trunk is so much cut through, that the slightest puff of wind lays it prostrate."[1]

The white-plumaged cockatoos, with conspicuous crests, tinged in part with orange, red, or yellow, pertain to the genus Plyctolophus, Vieil. (Plate CCCXCVII. fig. 3.) They inhabit New Holland and the eastern islands, and are remarkable for their great docility. They are said to prefer the vicinity of marshy places.

A beautiful small parrot, with longer legs than usual, and straighter claws, forms the genus Pezoporus, Illiger. It is green and yellow, spotted with black, the frontlet red, the tail long and graduated. The outer hind claw is very long. This singular bird, commonly called the ground parrot (*P. terrestris*, Shaw,—*P. formosus*, Latham), differs from its congeners in hardly ever perching upon trees. It remains upon the ground in sedgy plains, or runs among the long grass, almost after the manner of a rail. (Plate CCCXCVII. fig. 4.)

At the conclusion of the scansorial order Cuvier has placed two genera which have certainly but little in common with the preceding groups, and which some consider as allied to the gallinaceous order, while others have placed them in the conirostral tribe of Passeres,—we mean Corythaix and Musophaga. In both the bill is rather short, the upper mandible bulged or rounded, the feet have a short membrane between the toes, and although these are not placed exactly in pairs, yet the outer toe is versatile to a considerable degree. The nostrils are simply pierced in the corneous portion of the bill, the margins of which are dentated. In the plantain-eaters (genus Musophaga,

[1] *Wanderings in New South Wales*, &c. i. 182.

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Isert, Plate CCCXCVII. fig. 8) the base of the bill forms a raised, expanded disk upon the forehead. The violet plantain-eater (*M. violacea*) is a bird of great beauty, the general plumage being of a rich glossy violet black, the crown and primaries crimson, the bill yellow tipt with red, and a clear white stripe beneath the eye. It occurs in the province of Acra, in Guinea, and in other parts of Western Africa, and feeds on the fruit of the musa or plantain tree. The touracos (genus CORYTHAIX, Illiger, Plate CCCXCVII. fig. 7) want the expansion at the base of the bill, and have the head adorned by an elongated crest. Several beautiful species belong to this genus, such as the *Cuculus Persa* of Linn., a native of the Cape, —of a fine green colour, with a portion of the quill-feathers crimson. Vaillant informs us that there are great numbers of these birds in the country of the Kottinquas,— that they are very difficult to shoot, as they perch only on the summits of the tallest trees, and rarely suffer any one to approach within gun-shot,—but that they are easily caught alive in snares baited with such fruits as are in season. He adds, that they are excellent eating. Another species of this genus, which it is delightful to look upon, is the Pauline touraco, *C. Paulina*, also a native of Southern Africa. M. Vieillot, who had occasion to examine one alive in Paris, informs us that its manners were mild and familiar, that it lived on succulent fruits, and was fond of sugar. Its habits were active, its voice sonorous, and apparently ventriloqual.

ORDER IV.—RASORES.[1]

GALLINACEOUS OR RASORIAL BIRDS.

The species of this order, by far the most valuable to the human race of all the feathered tribes (how many, regardless of Ornithology, yet dwell with pleasure on a roasted turkey), are characterized by a rather short and convex bill. The upper mandible is somewhat curved, and furnished with a cere, sometimes naked, sometimes feathered. The head is generally small in proportion to the body. The nostrils are placed on each side of the bill, and usually in a fleshy protecting membrane. The tarsi are for the most part elongated. The toes are four in number, three of which are anterior, and united by a membrane more or less extended, at their bases; the fourth, posterior, is articulated higher than the others, and is in some cases very small, or even entirely wanting.

This order, as we have elsewhere noticed, contains several of the most ornamental, and a great majority of the most highly prized and useful species of the feathered race. While the peacock and golden pheasant stand unrivalled alike for elegance of form and beauty of plumage, the turkey and domestic fowl, the grouse quail and partridge, lay claim to more substantial though less sentimental regard, as conducing in no small degree to the social enjoyments of civilized life. Gallinaceous birds are generally distinguished by a bulky form, and a heavy and somewhat laborious flight. In fact, the sternum or breast-bone is so deeply notched on either side as to diminish the support afforded to the action of the pectoral muscles; and the power of the wings, and consequent duration and velocity of their movements, suffer a corresponding diminution.

With the exception of the alectors or curassoes, few of the gallinaceous species build on trees (in which they differ remarkably from the preceding orders), though all delight in basking on the ground, and scraping in the dry and sultry soil, for which purpose they are provided with muscular limbs and feet. They live upon all sorts of grain and seeds,—occasionally upon berries, or the buds of shrubs and trees,—and, the younger birds especially, show themselves sufficiently eager and expert in the capture of insect prey. The females lay a great number of eggs, in a rude and carelessly constructed nest; and the newly-produced offspring, unlike the callow nestlings of the other orders, though they remain for some time associated with their parents, run swiftly, and pick freely from their first exclusion. The males, particularly towards the breeding season, are quarrelsome and courageous,—indulging in frequent and sometimes fatal contention. They are often furnished with spurs. In the satyr pheasant both sexes are so armed, and the males are moreover provided with a couple of horns. In the polyplectron the tarsi of the male are doubly armed, there being two spurs on each leg.

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In their general form and habits, the particular structure and functions of the digestive system, and the great benefits which they confer upon the human race, birds of this order have been observed to bear a considerable resemblance to the ruminating or herbivorous quadrupeds. Like these, their stomach is of a more complex character, consisting of a dilated membranous pouch or crop, and a muscular gizzard,—in the former of which their food is rendered moist and pulpy, in the latter it is bruised and broken, and otherwise prepared for the production of the life-sustaining chyle; whereas in accipitrine birds the crop is either inconspicuous or non-existent, and the stomach, if not membranous, at least has its muscular coating very thin. The intestine in gallinaceous birds is rather long and wide, of nearly uniform diameter, and provided with two enormous cæca. Their flesh, we need scarcely say, is very delicate, and highly esteemed as a pleasing and nutritious food. It varies considerably in colour,— that of the turkey and common poultry being white, of the moor grouse brownish red, while the breast of the blackcock presents two distinct layers of red and white, the one imposed upon the other. We allude at present to its *culinary* aspect.

Naturalists have erred in assigning the polygamous habit as a general characteristic of our present order The instinct to pair, or habit of monogamy, is no doubt bestowed only on those species to which it is necessary for the sustentation of their young, and differs considerably in the nature and permanence of the attachment, according as the nest is placed above or upon the surface of the ground. All birds which build on trees, as was long ago observed by Lord Kames, are hatched blind, or extremely defective in the sense of sight, and almost without feathers,—thus requiring the sedulous care of both parents. But the generality even of gallinaceous birds, which breed upon the ground, do likewise pair, though the hatching of the eggs is entirely confided to the female, who completes her task by leading the young towards their proper food, which they are able to select for themselves, being active, completely formed, and well feathered, from their first exclusion. What is indeed more beautiful than the fond affection of these devoted creatures, teaching in the blindness of instinctive love, a lesson to proud but cold humanity? Who knoweth not (now divinely told) how the hen "doth gather her brood beneath her wings;" how she shelters them from the nipping blast, expanding her downy breast and feathery pinions, till she becomes a populous tabernacle, a living temple of maternal love, beset with small protruding bills, and bright but gentle eyes; how she will dare, with upraised ruffled plumes, the fiercest onset of the direst foe,—the callous school-boy with his threatening club, the snarling cur-dog with his ivory fangs, the insidious weasel, creeping serpent-like through tangled herbage, or the bolder bird of prey, "lord of the lion

[1] GALLINÆ, Linn.

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heart and eagle eye," descending swift and sure, like thunder-bolt from heaven! What are each or all of these in dread array, with death itself, to her at other times a fearful creature, but now pervaded by the deep intensity of mother love? Who knoweth not these things may have wandered far through wood and wilderness, up vast and lonely mountains, in moist and green savannahs, o'er dry and desert sands,—but he has never turned a kindly and considerate eye towards perhaps the too familiar features of some lowly farm-stead close by his early home. Yet to such thoughts the mind, in those that loved them once, not seldom turns. The hoary worn-out warrior, with "scars entrenched," and decked with emblems of the blood-stained field,—the smooth but hollow statesman, gorgeous on gala days in regal throngs,—the lawyer with insidious tongue, by which the worse is made the better reason,—the nabob "with visage discomposed," sallow as his gold (his heart as pure?),—the soft physician, with stilly foot and ever ready palm,—the merchant prince dreaming of "Tyre and Sidon," of freighted vessels, and "the injurious sea,"—think they not often of their boyish years, when one bright summer day seemed like a century of such delight as all their best planned schemes of proud ambition since then have yielded never? But in these fantastic thoughts forget we not our *gallinaceous order?*

The male, though somewhat less assiduous than the female, continues to manifest a certain degree of parental solicitude, by uttering the alarm note on the approach of birds of prey, or other dangerous foes. Black game and wood grouse, however, do not seem to pair at all, but in the genial spring a male assembles round him a certain number of devoted females, which afterwards deposit their eggs, and rear their young altogether independent of the male parent. These birds are therefore polygamous in the proper acceptation of the term. Indeed, even among herbivorous quadrupeds pairing is rare, because the female can suckle her young while she herself is feeding;—but the monogamous habit probably obtains among most carnivorous quadrupeds, and certainly among all carnivorous birds, because incubation leaves the female no sufficient time to hunt for food,[1] and because young birds cannot bear a long fast, and therefore require the assistance of both parents while unable to provide for themselves.

An extraordinary circumstance has been observed in the females of certain genera of this order, viz. an assumption of the male plumage after a certain period of life. We believe it to be a fact in the natural history of common poultry, that all hen-birds which either by accident or design have been allowed to attain the age of sixteen years complete, have been observed to assume the plumage of cocks! The same change has been seen to take place both in the female pheasant and the pea-hen, but at more indeterminate periods of life, and less in connection with an advanced age. Though these facts have not escaped the observation of the philosophical naturalist, yet the different circumstances attending their occurrence have not been detailed with sufficient frequency or fulness to admit of any satisfactory theory being offered in their explanation.[2] We shall conclude these general remarks by observing, that the gallinaceous order, with the exception of the pigeon tribe, and the genus *Opisthocomus* (*Thaozin*, Buffon), which certainly offer some very anomalous characters, is naturally and consistently composed. We shall now proceed to a brief notice of the principal genera.

The birds known by the general name of *Alectors* are species of large size from South America, somewhat allied to turkeys. Their tails are broad and rounded, and composed of large stiff feathers. They inhabit woods, living on fruits and buds, perching and building their nests on trees, and dwelling gregariously in love and amity. They are known under the by no means euphonious names of *hoccos* and *jacous* (words which we shall not pronounce except when necessary), and are arranged as follows by Baron Cuvier. The hoccos properly so called, which are also known as curassoes (genus Crax, Linn., Plate CCCXCVIII. fig. 1), have the bill strong, and its base surrounded by a skin sometimes of lively colour, and containing the nostrils. The head is ornamented by a tuft of long, narrow, recurved feathers. The most common kind is the *Crax alector*, or crested curasso, which was at one time almost completely acclimated in Holland, where they were as prolific as common poultry. It is so frequent in the woods of Guiana as to form, according to M. Sonnini, the surest resource of every hungry traveller whose stock of provisions may be found exhausted, and who has therefore become dependent on his gun. They are gregarious, and even when a considerable number have been shot, the rest will remain quietly perched, as if unconscious of the surrounding slaughter. Several other species are described in systematic works. *C. globicera* is distinguished by a large rounded tubercle on the base of the upper mandible.

In the genus Ourax, Cuv., the bill is shorter and thicker, with its basal membrane, as well as the greater portion of the head, covered with short, velvety feathers. (Plate CCCXCVIII. fig. 2.) Here is placed the *Ourax pauxi* (*Crax pauxi*, Linn.), or galeated curasso, a large turkey-like bird, with plumage of a shining black with green reflections, the abdomen and under tail-coverts white. At the base of the beak is a great oval tubercle, of a pale blue colour, and as hard as stone. The structure or position of the windpipe is peculiar. "Sa trachée," says Cuvier, "descend dehors, le long du côté droit jusqu'en arrière du sternum, se recourbe vers le côté gauche, et revient en avant pour rentrer dans la poitrine par la fourchette. Tous ces anneaux sont comprimés." This species is a native of Mexico, where it lives gregariously, perching on trees, but building usually on the ground, and leading about its young after the manner of the pheasant and common hen. It is easily domesticated.

The guans or yacous, genus Penelope of Merrem, have the bill more slender than the preceding, with a bare space around the eye, and on the lower part of the throat,—the latter generally capable of inflation. The individuals of the same species seem to vary considerably, so that many doubtful kinds have been described by naturalists. The guan, commonly so called (*Pen. cristata*, Gmelin), is the largest of the genus, measuring about thirty inches in total length. The whole upper surface of the body is of a dusky black or bronze colour, glossed with green and olive. The feathers on the back of the head form a thick erectile crest. The fore part of the neck and breast are spotted with white, each feather being surrounded by a white border. The naked part of the throat is bright scarlet, with a depending fold of the same colour. The manners of this bird resemble those of the curassoes. They search for food along the ground, but perch and build upon the tops of trees. They are less gregarious, generally keeping together in pairs, and remarkable, it is said, for the strictest constancy, and their strong attachment to each other,—being thus deserving of the name they bear, that of the devoted consort of Ulysses.

The genus Ortilda of Merrem scarcely differs from the preceding, except in having a much smaller portion bare around the eye and throat. We are acquainted with only a single species, the *Phasianus motmot* of Gmelin (*Phas. parragua*, Lath.). Its voice is very strong, and the windpipe descends beneath the skin towards the abdomen, and then remounts into the chest. The plumage is of a bronzed

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[1] See Kames's *Sketches*.

[2] Wilson's *Illustrations of Zoology*, vol. i. Order Gallinæ.

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brown above, and ashy-white below, the crest red. It inhabits Brazil, Paraguay, and Guiana. Two other species are described by M. Lesson, *Ort. Goudotii* and *squamata*,—the former inhabits the mountains of Santa Fé de Bogota, the latter is native to Brazil.[1]

The genus Opisthocomus of Hoffmansegg (*Sasa* of Vieil.) is associated in our present system with the preceding alectors. The only known species (*Phasianus cristatus*, Lath.) has the bill short and thick, the nostrils pierced in its corneous portion, without the usual surrounding membrane. The head bears a crest of long, slender, decomposed feathers, and the toes (in which character it also differs from all the genuine gallinaceous kind) have no connecting membrane at the base. The bird occurs in Guiana, where it is usually seen perched in places subject to inundation. It lives chiefly on the leaves and seeds of a species of arum. Its flesh has a strong smell of castoreum, and is used only as a bait for fishes. "Il forme," says Baron Cuvier, "un genre très distinct des autres gallinacées, et qui pourra devenir le type d'un famille particulière quand on connaitra son anatomie."[2] Its true situation in the natural system seems at present quite uncertain, but, from its great diversity in different works, must assuredly in some be most erroneous.

In the genus Pavo of Linn., the bill, of moderate size, is bare at the base, the nostrils lateral, sub-basal, open. The head is crested, the cheeks are naked, or nearly so. The tarsi are rather long, and armed with a conical spur. The upper coverts of the tail are of singular length and magnificence. The tail itself is erectile and wedge-shaped. The wings are rather short. This genus, as now restricted, contains only two species. The common peacock (*Pavo cristatus*, Linn.), so much admired for the surpassing splendour of its plumage, and now so familiarly known as a domestic bird, has probably been reduced to a state of dependence, if not of servitude, for some thousand years. The earliest notice we possess of it is contained in the second book of Chronicles. "For the king's ships went to Tarshish with the servants of Hiram: every three years once came the ships of Tarshish, bringing gold, and silver, ivory, and apes, and peacocks." The introduction of this beautiful bird to the western countries of Europe has never been clearly traced,—but every step of its progress has no doubt been owing rather to the agency of man than the instinct of nature. Its inborn tendency would clearly have been to return to whence it came,—to seek again the perpetual sunshine, and ever-verdant forests of Asia, the banks "of Ganges or Hydaspes, Indian streams." It appears to have been unknown even in Greece during the early manhood of Alexander the Great, by whom it was first observed with no less wonder than delight in the progress of his southern expedition, and then transmitted to his native country. There, however, it must have multiplied speedily, as Aristotle, who died in a year or two after "the great Emathian conqueror," mentions the peacock as a well-known bird. It is now distributed among most civilized nations, beautifying with lustrous train our verdant lawns, and arching its proud emblazoned neck among the "ancestral trees" of many lordly dwellings. The cry of the peacock, unless when mellowed by distance, is harsh and unmusical, but extends far and wide. Indeed the notes of all birds, whether musically toned or inharmonious, are very clear and forcible. The voice of a blackbird may be heard as far as that of a man,—the clanging cry of the stork has been calculated to fill a circumference of nearly half a league, and the harsh scream of the peacock extends as far as that of an elephant.[3] Mr Waterton observes, that the singular metallic note of the campanero or bell-bird of America is audible from a distance of three miles.

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The only other species of this genus (as now restricted) is the Japan or Javanese peacock (*P. Japonensis*, Briss.,—*P. Javanicus*, Horsfield), of which we have elsewhere figured both the adult male and young, under the name of Aldrovandine peacock, from the specimens in the Edinburgh Museum.[4] It occurs in Japan, Java, and other eastern and southern regions of Asia. The particular markings and general distribution of the colours in the train scarcely differ from those of the better-known species; but the Aldrovandine bird may be distinguished at first sight from the common kind, by a difference in the form, colour, and consistence of the cervical feathers; by the shape and structure of the occipital crest, of which the plumes are lance-shaped, or broadly linear, and barbed throughout their entire length, instead of being merely tufted at the extremities; by the dissimilar plumage of the wing-coverts, and the number of feathers in the tail, which in the former consists of twenty, in the latter of only eighteen.

The genus Polyplectron, Temm., contains a few species formerly classed with the preceding, but of smaller size, and distinguished by a pair of spurs on each tarsus. Such is the beautiful Thibet peacock (*Pol. Thibetanus*), the peacock-pheasant of Edwards, of which a great proportion of the plumage is ornamented by large and very brilliant spots of greenish blue, changing with the varying light to gold and purple, and surrounded by circles of black and yellowish white. The male is about the size of the golden pheasant. The plumage of the female is less brilliant, and her tail shorter. The colour in the young of both sexes is earthy gray, with large spots and small lines of brown. This species is of easy domestication, and not remarkable for shyness even in a state of nature. It is native to the mountains of Thibet, and is said also to occur in China. At least it is frequent in the aviaries of that leaf-soaking people.

The genus Lophophorus, Temm., distinguished by its tufted hanging crest, and strongly bent and broadly margined bill, contains that splendid bird the Impeyan pheasant (*Loph. refulgens*), of which the colours of the plumage are so exceedingly brilliant from their metallic lustre, and so variable according to the direction of the light or the position of the spectator, that they cannot be expressed by words, and even the skill of the most accomplished painter would in vain attempt to equal the bright original. Purple, green, and gold, are the prevailing hues. The female, however, is almost entirely destitute of metallic splendour. This bird inhabits the mountains in the northern parts of Hindustan. Lady Impey endeavoured to transport it alive to England, but it died on the passage. It is known to the natives by the name of *monaul*, which signifies the bird of gold.

The genus Meleagris, Linn., distinguished by its bare and wattled head and neck, and broad erectile tail, contains the valuable but unromantic turkey, *M. gallo-pavo*, Linn., a heavy and ungraceful bird, as it exists in the poultry-yards of Britain, but of a richer plumage and more powerful wing in its native wooded wilderness. "The wild turkey," observes Mr Nuttall, "once prevalent throughout

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[1] *Dictionnaire des Sciences Nat.* t. lix. p. 195.

[2] *Règne Animal*, t. i. p. 473, note.

[3] We have few opportunities (fortunately) afforded us in this country of judging of the strength of voice in wild beasts. Our own experience extends only to the following homely fact, which, however, it may be worth while to mention. During the residence in Edinburgh of Mr Wombwell's and other travelling menageries, we have endeavoured to test the extension of the lion's voice from different quarters. We have often heard it very distinctly on a still evening, about feeding time, from the top of Craigleith quarry, distant from the menagerie (on the Mound, Princes Street) about two miles and a half.

[4] *Illustrations of Zoology*, vol. i. pl. 14, 15.

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the whole continent of North America, from Mexico and the Antilles to the forests of Lower Canada, is now, by the progress and density of population, chiefly confined to the thickly wooded and uncultivated tracts of the western states, being particularly abundant in the unsettled parts of Ohio, Kentucky, Illinois, Indiana, and throughout the vast forests of the great valleys of the Mississippi and Missouri. On the banks of the latter river, however, where the woods disappear beyond the confluence of the Platte, the turkey no longer appears, and the feathers of the wings, for the purpose of pluming arrows, form an article of small commerce between the other natives and their western countrymen. For a thousand miles up the Arkansas and Red River, in the wooded alluvial lands, they are not uncommon. They are likewise met with in small numbers in Tennessee, Alabama, and West Florida. From the Atlantic states generally they are now nearly extirpated. The wild turkey is neither gregarious nor migratory, but from the necessity of wandering after food; it is otherwise resident throughout the whole of the vast region it inhabits, including the greatest diversity of climate; and it is prolific in proportion to its natural resources, so that while in the United States and Canada it only breeds once in the year, in Jamaica and the other West India islands it is said to raise two or three broods in the same period. In quest of mast, they therefore spread themselves through the country, and insensibly assemble in considerable numbers to the district where their food abounds. These movements are observed to take place in October (the turkey moon of the aborigines). The males, or *gobblers* as they are often called, from their note, are now seen apart from the other sex, in companies varying from ten to a hundred. The females move singly, or accompanied by their almost independent brood, who all at first shun assiduously the persecuting society of the selfish male. Yet after a while, when their food proves abundant, separate mixed flocks of all ages and sexes often promiscuously join in the bounteous repast. Their migration, very unlike that of the rapid pigeons, is made almost entirely on foot, until their progress is perhaps arrested by a river. Their speed, however, is very considerable, and when surprised, they more commonly trust to their legs than their wings, running nearly with the velocity of a hound. On meeting with an impediment of this kind, after considerable delay, they ascend to the tops of the tall trees, and, at the cluck of the leader, they launch into the air for the opposite shore. The transit is a matter of little difficulty, though considerable labour, for the older birds; but the younger and less robust sometimes fall short of the bank, and are either drowned or attain the land by swimming. After crossing, it is remarked that they often become an easy prey to the hunter, as they seem bewildered by the new country in which they have arrived, or more probably are fatigued by the novelty and extent of their excursion. After long journeys and privations, particularly in frosty weather, or while the ground is covered with snow, they are sometimes reduced to the necessity of making their appearance near farm-houses, where they now and then even associate with the poultry, and enter the stables and cribs after grain. In this desultory and foraging manner they spend the autumn and winter.

"According to the latitude, and the advancement of the season, though always very early in the spring, they begin to be actuated by the instinct of propagation. The males commence their gobbling, and court the society of their retiring mates. The sexes roost apart, but in the same vicinity, and at the yelp of the female the gobbling becomes reiterated and extravagant. If heard from the ground, a general rush ensues to the spot, and whether the hen appears or not, the males, thus accidentally brought together, spread out their train, quiver and depress their rigid wings, and strutting and puffing with a pompous gait, often make battle, and directing their blows at the head, occasionally destroy each other in a fit of jealousy. As with our domestic fowls, several hens usually follow a favourite cock, roosting in his immediate neighbourhood, until they begin to lay, when they withdraw from his resort to save their eggs, which he would destroy if discovered.

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"The females are therefore seen in his company only for a few hours in the day. Soon after this period, however, the male loses his ardour, and the advances of affection now become reversed, the hen seeking out the society of her reluctant mate. In moonlight nights the gobbling of the male is heard, at intervals of a few minutes, for hours together, and affords often a gratifying means of their discovery to the wakeful hunter. After this period the males become lean and emaciated, so as to be even unable to fly, and seek to hide themselves from their mates in the closest thickets, where they are seldom seen. They now also probably undergo their moult, and are so dry, lean, and lousy, until the ripening of the mast and berries, as to be almost wholly indigestible, and destitute of nutriment as food. So constant is this impoverished state, that the Indians have a proverb, 'As lean as a turkey in summer.'

"About the middle of April, in Kentucky, the hens begin to provide for the reception of their eggs, and secure their prospects of incubation. The nest, merely a slight hollow scratched in the ground, and lined with withered leaves, is made by the side of a fallen log, or beneath the shelter of a thicket, in a dry place. The eggs, from ten to fifteen, are whitish, covered with red dots. While laying, the female, like the domestic bird, always approaches the nest with great caution, varying the course at almost every visit, and often concealing her eggs entirely by covering them with leaves. Trusting to the similarity of her homely garb with the withered foliage around her, the hen, as with several other birds, on being carefully approached, sits close without moving. She seldom indeed abandons her nest, and her attachment increases with the growing life of her charge. The domestic bird has been known not unfrequently to sit stedfastly on her eggs until she died of hunger. As soon as the young have emerged from the shell, and begun to run about, the parent, by her cluck, calls them around her, and watches with redoubled suspicion the approach of their enemies, which she can perceive at an almost inconceivable distance. To avoid moisture, which might prove fatal to them, they now keep on the higher sheltered knolls; and in about a fortnight, instead of roosting on the ground, they begin to fly at night to some wide and low branch, where they still continue to nestle under the extended wings of their protecting parent. At length they resort during the day to more open tracts, or prairies, in quest of berries of various kinds, as well as grasshoppers and other insects. The old birds are very partial to pecan-nuts, winter grapes, and other kinds of fruits. They also eat buds, herbs, grain, and large insects; but their most general and important fare is acorns, after which they make extensive migrations. By the month of August the young are nearly independent of their parent, and become enabled to attain a safe roost in the higher branches of the trees. The young cocks now show the tuft of hair upon the breast, and begin to strut and gobble, and the young hens already pur and leap. One of the most crafty enemies which the wild turkey has to encounter is the lynx or wild cat, who frequently seizes his prey by advancing round, and waiting its approach in ambush. Like most other gallinaceous birds, they are fond of wallowing on the ground, and dusting themselves.

"When approached by moonlight, they are readily shot from their roosting-tree, one after another, without any

Rasores. apprehension of their danger, though they would dodge or fly instantly at the sight of the owl. The gobblers, during the season of their amorous excitement, have been known even to strut over their dead companions while on the ground, instead of seeking their own safety by flight. In the spring, the male turkeys are called by a whistle made of the second joint bone of the wing of the bird, which produces a sound somewhat similar to the voice of the female; and on coming up to this call they are consequently shot. They are likewise commonly caught in quadrangular pens made of logs crossing each other, from which is cut a slanting covered passage sufficient to allow the entrance of the turkey. Corn is then scattered in a train to this cage for some distance, as well as within; and the neighbouring birds, in the surrounding woods, having discovered the grain, call on each other by a clucking, and entering one at a time, they become secured in the pen, as, for the purpose of escape, they constantly direct their view upwards, instead of stooping to go out by the path by which they had entered. The male wild turkey weighs commonly from fifteen to eighteen pounds, is not unfrequently as much as twenty-five, and sometimes, according to Audubon, even thirty-six. The hen commonly weighs about nine pounds; and the usual price for a turkey from the Indians is twenty-five cents."[1]

The only other species of turkey is a very rare and beautiful bird (*M. ocellata*, Cuv.), of which, we believe, only a single specimen is yet known. It was captured by the crew of a vessel who were cutting wood in the Bay of Honduras, and was brought alive to the Thames, for presentation to Sir Henry Halford, but met with an accident which caused its death. It afterwards became the property of Mr Bullock; and on the dispersion of his collection, was purchased by the French government for the Paris Museum. It is nearly equal in size to the common turkey. The tail is less ample, but its colours are more varied and beautiful, almost rivalling those of the peacock in its little mirrors of sapphire, surrounded by circles of gold and ruby.[2]

The species known to us by the name of Guinea fowls, form the genus Numida, Linn. The head is bare, the top in some crested, and the throat wattled. They are all either from Africa or Madagascar.

The great genus Phasianus, Linn., including our cocks and pheasants, has the cheeks more or less bare of feathers, usually covered by a scarlet skin, and the tail-feathers so placed as to slope downwards, roof-like, from either side. The group was soon found to be too extensive and varied in its component parts to accord with the preciser views of modern times, and several subdivisions have been in consequence effected.

The restricted genus Gallus, for example (Plate CCCXCVIII. figs. 3 and 3 *a*), of which the head is generally surmounted by a fleshy vertical crest, the base of the lower mandible furnished with two flattened wattles, and the tail-feathers, fourteen in number, rising in two almost upright planes, with ample coverts in the male sex, contains, among other remarkable species, our domestic *cock and hen* (*Gallus domesticus—Phasianus gallus*, Linn.). The general attributes or special qualities of this brave, vigilant, and invaluable species, need not be here recorded; and indeed a volume would scarcely suffice to describe its numerous variations, from the pure undaunted blood of Derby, fearless of death, to the crested dung-hill breed, almost equally pugnacious, and by no means cowardly, yet apt to turn tail on the sudden touch of unexpected steel.

In our present paragraph we avail ourselves in part of a recent brief compendium. The cocks with ample crests, and five toes,—the rumpless cock, and those of many-mingled colours,—appear to have arisen chiefly from the various and prolonged circumstances attending domestication, and the intentional crossing of the breeds. The most picturesque are those with superabundant crests, and full auricular plumes. The crest is composed of narrow, hackled feathers, which grow erect from the head, but fall down in graceful curves, sometimes of such length as to shadow or overhang the eyes. In some districts this breed is much cultivated, being esteemed in proportion as the colours of the body and crest can be made to form the most conspicuous contrast, the body black, the crest white, and *vice versa*. Other admired fancy breeds are the Dutch pencilled fowl, which are pure white, with black spots; the Siberian fowl, with long tufts of hanging feathers springing from the lower jaw; and the Barbary fowl, of a pale dun colour, with the feathers of the neck extremely ample, and spotted with black. But a more singular anomaly is exhibited by those with five toes, commonly called *dorkings*, from being bred in most abundance in the neighbourhood of Dorking, Surrey. This race is easily continued, and is much esteemed for the table, being white and large. Dr Latham records one which weighed nearly fourteen pounds. A still more remarkable race is that without a tail, the rumpless or Persian cock, as it is sometimes called, which actually wants a portion of the caudal vertebræ. These are usually regarded as mere varieties, for the most part, probably, of accidental origin. There are, however, three races of cocks, of a very marked character, although their claim to actual specific distinction cannot be yet made out. The first is *Gallus morio*, of which the periosteum of the bones is black, and the comb, wattles, and skin, of a dull purple. It has received the name of negro or blackamoor cock, but is scarcely ever seen in the poultry-yards of this country. The other two races are more frequent, and are known as the silky cock (*G. lanatus*), and the Friesland cock (*G. crispus*). M. Temminck is inclined to regard the former as a distinct species. It occurs in China and Japan, where it is sold as a rarity to Europeans. In this country it crosses easily with the white domestic breed, and a mixed race is produced with the feathers still silky, but less disunited. It is singular that the skin and periosteum of this kind are of the same sable hue with those of *G. morio*, although the flesh is remarkable for its whiteness. The size is rather small, the plumage of the purest white, the comb and wattles purple. The Friesland cock evidently belongs to the opposition, having all the feathers turned the wrong way, or standing nearly at right angles with the body. The general colour of the plumage of this kind is also white, but it varies like that of other captive races. It occurs in the domesticated state in Java and Sumatra; but M. Temminck thinks it is also a distinct species, peculiar in the wild state to some unexplored quarter of the Indian islands.[3] We doubt that nature, in her first intent, should ever have produced such an oddity.

Many fanciful and superstitious feelings are still maintained regarding the domestic cock, and his nocturnal crowing; and even his more familiar morning salutation is supposed to dispel all spirits, "whether in sea or fire, in earth or air."

> Some say that ever 'gainst that season comes
> Wherein our Saviour's birth is celebrate,
> The bird of dawning singeth all night long;
> And then, they say, no spirit walks abroad;
> The nights are wholesome; then no planets strike;
> No fairy takes, nor witch hath power to charm;
> So hallowed and so gracious is the time.

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[1] *Manual*, vol. i. p. 640.

[2] *Mém. du Museum*, vi. pl. 1; and *Pl. Col.* 112.

[3] *Naturalist's Library*, vol. iii. p. 173.

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Of the numerous benefits which the goodness of God has enabled man to derive from the wide circle of the feathered race, there is probably none which surpasses, either in extent or utility, the domestication of these most familiar birds. Of so long standing, however, has been the subservience of the race to man, that no authentic traditionary traces now remain of its original introduction to any of the more ancient kingdoms of the earth,—its existence under human guardianship seeming indeed coeval with the most antique records. It may therefore be regarded as one of those particular and providential gifts, which, like the faithful and accommodating dog, was at an early period of the world added to the fortunes of the first families of the human race, and has since followed man in his wonderful and far-spread migrations through every clime and country. For some thousand years the observers of nature were ignorant of any wild species which, even in a remote degree, resembled any variety of the domestic breed,—and from the era of Herodotus to that of Sonnerat, the domestic cock and hen might have been regarded as birds, the living analogues of which were no longer known to exist in a natural and unsubdued condition.

In consequence of the remote obscurity in which the subject is thus involved, few points in natural history have occasioned more inconclusive speculation, or are even now more difficult to solve with certainty, than the source from which we have primarily derived our different races of domestic poultry. That they came originally from Persia, has been inferred from the circumstance of Aristophanes calling the cock "the Persian bird." Such an origin, however, is improbable, when we consider that the researches of modern travellers, and indeed of all who have visited that country since the revival of learning, have failed to discover there any species of wild poultry,—no gallinaceous bird being found in Persia more nearly allied to the genus Gallus, than a species of *Lophophorus*. If, however, it is merely meant that the Greeks, during the intercourse, hostile or otherwise, which existed between them and the Persian nation, may have obtained a breed previously domesticated, the idea is less objectionable; for it is known that in a domestic state poultry have existed in Persia from a very remote antiquity.

It appears from an ingenious dissertation by the late Dr Scot of Corstorphine, to have been the opinion of that learned Hebraist, that poultry were unknown to the Jews, or at least that they are not distinctly alluded to in the Old Testament. It cannot, however, admit of a doubt, that they were well known over many parts both of Europe and Asia for several hundred years before the Christian era. When Themistocles took the field to combat the Persians, he alluded, while haranguing his troops, to the invincible courage of the feathered biped. "Observe with what intrepid valour he fights, inspired by no other motive than the love of victory; whereas you have to contend for your religion and your liberty, for your wives and children, for the tombs of your ancestors;" and it was on this occasion that the Athenians achieved one of the most memorable victories recorded in history. According to Ælian, it was in commemoration of this signal event, and of the *ornithological* image by which the courage of the soldiery had been excited and sustained, that the Athenians instituted those annual games of which cock-fighting formed so conspicuous a feature. Now Themistocles died in the sixty-fifth year of his age, and about the 449th year preceding the Christian era, and must consequently have been contemporary with Nehemiah the prophet; and as the Old Testament history does not conclude till about twenty years after the death of Themistocles, it may be inferred, that if the later of the sacred historians do not mention poultry, it must be from some other cause than ignorance of their existence,—seeing that as the early Greek nations had received them prior to that period, either from Persia or the more south-eastern countries of Asia, they could scarcely have remained unknown in the *intermediate* regions inhabited by the Jews. For these and other reasons, which it would here be tedious to detail, we do not agree with Dr Scot.

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In regard to the natural origin of these domestic birds, the first approximation to the truth (and we deem it but an approximation) resulted from the discovery by Sonnerat of a species of wild poultry native to the mountains of the Ghauts, in India. This is the *Gallus Sonneratii* of systematic naturalists, better known to British residents by the now familiar name of *jungle-cock*. Our knowledge of gallinaceous birds, however, has so greatly increased during recent years, and so many additional species have been discovered, that we are able to proceed upon much more certain ground than were the naturalists of the last century. The jungle-cock is not only no longer the only claimant to the long dormant title which, under whatever name of honour, may be due to the species so greatly beneficial to the human race, but other aspirants have come forward with such better-founded claims, that his may fairly be regarded as altogether set aside. In fact, several important characters of the jungle-cock have never been traced in any of the domestic varieties, and many of these latter present features which, if not incompatible with, at least bear no resemblance to any attributes of the supposed original. We may here observe, that the natural *form* and *structure* of any portion of the animal organization are much less easily effaced or altered than the more superficial character of *colour*; and hence, if a particular species of bird be naturally distinguished by a peculiar consistence as well as colour of plumage, the influence of those causes which produce variation less frequently affect the former than the latter. Reasoning therefore *a priori*, it would be more natural to expect that if the jungle-cock were the parent of our domestic breeds, such breeds, however they might vary in the colouring of their plumage, would at least at times exhibit those marked and peculiar characters of form and structure by which the feathers of the supposed original are distinguished. This, however, is not the case. Amid the infinite varieties which occur among our domestic poultry, the plumage of none is found characterized by those horny laminæ, or expansions of the shaft, which form so marked a feature in the plumage of the jungle-cock, and which assuredly would have either continued a permanent feature, or been occasionally manifested in one or other of our domestic breeds, had these been derived from the species in question. We may mention another circumstance on which we believe we were ourselves the first to insist.[1] The native tribes of Indians inhabiting the districts where the jungle-cock abounds rear a breed of poultry which differs as much from the supposed original as our own, and which never intermingles with the forest brood.

According to M. Temminck (and in this we quite agree with that industrious and observant naturalist), the species to which our domestic races are most nearly allied, are the *Jago cock* of Sumatra (*Gallus giganteus*), a wild species of great size, and the *Bankiva cock* of Java, another primitive species, which occurs in the forests of the last-named island (see Plate CCCXCVIII. figs. 3 and 3*a*. There are several circumstances which render the claims of these two birds much stronger than those of the jungle-cock. 1*st*, Their females bear a strong resemblance to our domestic hens; 2*dly*, the common village cock, in its most ordi-

[1] See our Essay "On the Origin of Domestic Poultry," in the *Wernerian Memoirs*, vol. vi. p. 402.

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nary condition, is intermediate, in respect to size, between these two species; 3*dly*, the nature of the plumage, which in its form, consistence, and distribution, is absolutely the same as in the common cock, greatly strengthens the supposition; 4*thly*, it is in these species alone that we find the females, as well as males, provided with a fleshy crest and small wattles,—characters which likewise distinguish both sexes of our common poultry, although they are for the most part but slightly developed in the females. Now the female jungle-cock possesses neither comb nor wattles.

It may be stated as a curious though well-known fact, that when Captain Cook first visited the South Sea Islands, he found them well stocked with domestic poultry; and the more recent as well as more ample narratives of the missionaries have confirmed the statements of the great navigator regarding the practice of cock-fighting in Otaheite, and other islands of Polynesia. Mr Ellis describes the *Faa-ti-to-raa-moa*, or literally the causing fighting among fowls, as the most ancient game of the Tahitians; and he informs us, that according to the tradition of the natives, poultry have existed in the islands as long as people,—that they either came with the first colonists, or were produced by Taaroa contemporaneously with men. Long before the first foreign vessel was seen off their shores, they were in the practice of training and fighting cocks. However, they never trimmed, as we do, their flowing plumes, but were proud to see the beautiful and gorgeous combatants with ample natural wings, full-feathered necks, and lengthened tails. We may observe, that the breed of these islands do not appear to have been what in this country we would denominate *game;* for Mr Ellis (in his *Polynesian Researches*) incidentally mentions, that as soon as one bird *avoided* another, he was considered as *vi*, or beaten, and victory was declared in favour of his opponent. It is indeed a singular circumstance that this barbarous practice should have pervaded so many unconnected nations, both savage and civilized. It has entirely ceased among the inhabitants of the Friendly and Society Islands since the establishment of Christianity, although still pursued by the practical heathen of other and more ancient Christian lands. We ourselves, to our shame be it spoken, once fought a main of cocks with an English clergyman, who has since held a high and conspicuous station in the church. We believe, indeed, that he is now a bishop,—haply forgetful of us and of our famous *Faa-ti-to-raa-moa*.

In the genus Phasianus properly so called, the sides of the head around the eyes are covered for a space by a naked warty skin. The tail is very long and slender, each feather laterally inclined or roof-shaped, and the central pair usually much prolonged. The common pheasant of our coverts (*Ph. colchicus*) is the most familiar example. This bird is now well known in most of the temperate parts of Europe, though originally introduced from the banks of the Phasis (now the Rioni), a river of Chalcis in Asia Minor. Need we describe his glowing bright attire?

> Splendid his form, his eyes of flaming gold
> Two fiery rings of living scarlet hold;
> His arching neck a varying beauty shows,
> Now rich with azure, now with emerald glows.
> His swelling breast with glossy purple shines,
> Chesnut his back, and waved with ebon lines;
> To his broad wings gay hues their radiance lend,
> His mail-clad legs two knightly spurs defend.

The variety called the ring-pheasant (*Ph. torquatus*), characterized by a more or less completed circle of white around the lower portion of the neck, is by some regarded as a distinct species. The gold and silver pheasants of our aviaries (*Ph. pictus* and *nycthemerus*), and several other still more magnificent birds, on the beauty of which we regret we cannot here dilate, pertain to our present genus.

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One of the most singularly superb of all the gallinaceous order, we mean the argus pheasant, now forms a separate genus under the name of Argus. Of this rare and remarkable bird (*A. giganteus*, Temm.) China and the adjoining provinces of Tartary have been assigned as the native country by various writers. This, however, requires confirmation, as all the specimens of which the origin is accurately known have been brought from the great eastern islands and peninsula of Malacca. There is a passage in Marco Polo's *Travels*, which may perhaps be construed as relating to the bird in question. In his description of the kingdom of Erginal (a district of Tangout, in the northwest of the empire), he observes, "pheasants are found in it that are twice the size of ours, but something smaller than the peacock. The tail-feathers are eight or ten palms in length." "This," observes Mr Marsden, the learned editor of the English edition, "is probably the Argus pheasant, which although a native of Sumatra (where I have frequently seen it alive), is said to be also found in the northern part of China."[1] Though of late years well known in the *Basses-cours* of Batavia (from which M. Temminck received a splendid series), we are not aware that the Argus has been ever imported alive into Europe. It would certainly prove a more magnificent addition than any which has been made to our aviaries in modern times. The great apparent size of this bird arises chiefly from the peculiar formation of the wings, of which the secondaries are three times the length of the primaries, being nearly three feet long. In consequence of the unwieldy extent of that portion of the wing which is not under the immediate influence of muscular action, this magnificent bird is alleged to be almost destitute of the power of flight. Its progress, however, when running on the ground, is greatly accelerated,—the expanded secondaries, according to M. Temminck, acting as powerful and capacious sails, and furnishing a very fleet and effectual mode of transportation. The body, when stripped of the feathers, scarcely exceeds that of a barn-door fowl, but in its "high and *plumy* state" it measures in total length about five feet three inches,—the tail-feathers being themselves nearly four feet long. The female is, as usual, less adorned. Her secondaries want the peculiar breadth and extension, as well as the beautiful eye-like markings which adorn the male. In consequence, however, of this homely appearance, she is less frequently sought for in her native forests, and is thus (in collections) by far the rarer of the two. M. Temminck, for example, thought himself fortunate in finding a brace of females among thirty males.

In the genus Euplocomus, Temm., the head is crested, the tail much broader than in the true pheasants, and sometimes forked. The beautiful Macartney cock, or fire-backed pheasant (*Eu. ignitus*), is the most characteristic, if not the sole example. It was met with by Sir George Staunton in a menagerie at Batavia, and is believed to be a native of Sumatra.[2]

The horned pheasant of Edwards and Latham has been made by Cuvier to constitute the genus Tragopan. The head, though crested, is elsewhere almost naked; a little slender horn projects backward from behind each eye, and a loose and pendent skin, inflatable at pleasure, hangs from the base of the lower mandible (see Plate CCCXCVIII. fig. 4). The group now consists of about four species, all remarkable for their richly varied and beautifully spotted plumage. They are bulkier birds than pheasants, with rounded tails of ordinary length. The females of such as are known are brindled with brown and black. We have yet learned nothing of the habits or natural economy of the Tragopans, although their external aspect has been rendered familiar in elegant representations by Mr Gould.[3] The

[1] *Travels*, pp. 225–9. [2] *Embassy to China*, pl. xiii. [3] *Century of Birds from the Himalaya Mountains.*

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first discovered species (*T. satyrus*), though usually brought from Nepaul, has been ascertained also to inhabit Thibet; and Chinese specimens from the mountain province of Yunnan were seen by Mr Bennet in Mr Beale's aviary at Macao.[1]

The genus CRYPTONYX, Temm., has a bare space around the eye, the tail of medium size and flat, and the tarsi without spurs; but the most peculiar character consists in the hind toe being destitute of claw. The best-known species is *C. coronatus*, or *rouloul* of Malacca (see Plate CCCXCVIII. fig. 5). The female is described by Latham under the title of *Tetrao viridis*. It inhabits deep forests, is wild and cunning in a state of nature, and in confinement impatient of restraint.

The great genus TETRAO of Linn. has also been greatly subdivided in recent times. All the species seem to agree in having a bare band above the eye.

The restricted genus TETRAO has the legs covered with feathers, and without spurs. In some the toes are naked, and the tail either forked or rounded. Such is the great wood grouse or capercailzie (*T. urogallus*), the largest and finest example of the gallinaceous order indigenous to Europe. In Britain it has been long extinct in the wild state (although of late several times imported with a view to re-establish the breed), and now occurs chiefly in Scandinavia, although not unknown among mountainous and woody regions southwards, as far as the Alps of Savoy and the Veronese. Although rather difficult to rear in Britain, the capercailzie is often domesticated in Sweden, where it becomes so tame as to eat familiarly from the hand. Though naturally shy and wary, they sometimes, even in their unreclaimed condition, manifest a singular and unaccountable degree of boldness. Mr Brehm mentions a cock bird that inhabited a wood near Renthendorf, through which there was a roadway, and whenever any one passed through, it would fly towards him, peck at his legs, and strike him with its wings. The black-cock (*T. tetrix*) is a smaller, but very beautiful species, of hardy habits, and much on the increase in many parts of Britain, where it prefers alpine pastures, with a sprinkling of natural wood, intermingled with moist places covered by long coarse herbage. It is widely dispersed over the northern and temperate parts of Europe, and spreads somewhat farther south than the preceding, being found, though rarely, on the Apennines. We know that it breeds among the lofty hills above Albenga, near the Colle de Tende. Other species of bare-toed grouse occur in Europe, and a still greater number in North America. For the history of the latter we must refer to the well-known works of Alexander Wilson, C. L. Bonaparte, Audubon, Richardson, and others.

Of the feather-footed game-birds (genus LAGOPUS), the most noted for gastronomic excellence is our common red grouse, or moor-game (*L. Scoticus*), so highly prized and eagerly pursued by sportsmen. This well-known species restricts itself chiefly to the sides of sloping mountains, and those extensive tracts of elevated land called moors, where it is careless of other shelter than that afforded by the natural roughness of the ground, and its plentiful covering of heath, or other alpine plants of still more lowly growth. The most singular fact in its history is its restriction to Great Britain and Ireland,—all other parts of the world, from "Indus to the pole," being sought in vain for a single example. In this little group we also place the ptarmigans, distinguished from the other grouse by the assumption of a snow-white plumage during winter. These birds seem to prefer, in comparatively temperate climates, such as that of Scotland, the bare and stony sides or summits of the highest mountains; but under the rigorous temperature of Greenland, and the most northern portions of America, they are chiefly found in the vicinity of the sea-shore, by the banks of rivers, and among the willow and other copse woods of the lower and more sheltered vales. The species of Europe and America are not yet in all respects sufficiently characterized and distinguished.

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The genus PTEROCLES, Temm., has a naked space around the eye, but not of a scarlet colour, as in grouse; the toes are bare, the hind one very small, and the tail pointed (Plate CCCXCVIII. fig. 6). These birds, called gangas, or sand-grouse, live in sandy plains and deserts in the warmer regions of Asia and Africa, although two species, *Pt. arenarius* and *setarius*, Temm., inhabit some of the southern countries of Europe, especially Spain. The latter is the pin-tailed grouse of Latham, *Tetrao alchata*, Gmelin.

The genus PERDIX of Brisson contains the partridges, distinguished by having the legs or tarsi bare, as well as the toes. The tail is also very short, although of greater length among the kind called francolins, and other foreign species. Of these several are armed with spurs; and one especially, the sanguine partridge (*P. cruentata*, Temm.), has sometimes three or four spurs on each leg. The francolins perch on trees. The partridges properly so called always rest upon the ground. Their bill is not so strong, and their spurs, if they have any, are very short, or simply tubercular. Four or five sorts are found in Europe, although the common gray partridge (*P. cinerea*) is our only truly indigenous kind. The red-legged partridge (*P. rubra*), which in Italy is the most frequent, has been introduced of late years into the south of England, where it continues to breed spontaneously in a state of nature. Many other species occur in foreign countries.

The quails (genus COTURNIX) are of smaller size than the preceding, the tail is still shorter, the spurs are wanting, and there is no coloured space above the eye. The only British species is the common quail (*C. Europeus*), a well-known bird of passage, generally but not abundantly distributed over the island. In Scotland it is even scarce, although we have found it occasionally near Edinburgh, as well as in Ross-shire, and along the coasts of Aberdeen and Kincardine. The whole migrate from the colder and temperate parts of Europe during autumn, and re-appear in spring, in certain places, in enormous numbers. Along the Neapolitan coasts, for example, 100,000 have been taken in a single day. In some of the southern countries of Europe, however, many quails remain throughout the winter. In Portugal they are even more numerous during that season than in summer; and Signor Savi says, in regard to those of Italy, "Sono le quaglie uccelli viaggiatori, giacchè la massima parte lasciano l'Europa, traversano il mare, e vanno a passare il verno in Affrica, ed in Asia; ma di Toscana, come pure dalle altri parti meridionali, non partono tutti, anzi una gran quantità ne resta per le stoppie delle nostre Maremme, ove trovano e molto nutrimento e dolce clima. Negli ultimi giorni d'Aprile si rimetteno in moto; quelle che avevan passate il mare lo passan di nuovo, e quelle che eransi ritirate ne' siti aprici si spargon per tutti i campi e prati."[2] A vast number of quails of various kinds are found in foreign countries. A beautiful small species (*C. excalfactoria*, Temm.,—*P. Chinensis*, Lath.) is very abundant in China, where it is bred in the domestic state, and kept in cages for the singular purpose of warming people's hands in winter. It is also patronised on account of its pugnacious disposition, being fought with its own kind, as common cocks are in this country.

The American quails now form the genus ORTYX, and are in some measure intermediate between the true quails and partridges. The bill is thick and strong, but short

[1] *Wanderings*, &c. vol. ii. p. 61.

[2] *Ornitologia Toscana*, tom. ii. p. 200.

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and rounded; the tail more lengthened than in those of the old continent. One species, *O. Californica*, has the head ornamented by a beautiful slender recurved crest. (See Plate CCCXCVIII. fig. 7.) Several other kinds were recently discovered and described by the lamented Douglas, the botanical traveller and collector, whose tragical fate in the Sandwich Islands recently excited the sympathy of the scientific world. They differ from the ordinary quails in usually perching upon trees at night. The Virginian Ortyx, *O. borealis*, has of late years been reared in several parts of England, and is now almost naturalised in Sussex. It is considerably larger than the common quail.

The genus Ortygis of Illiger resembles the quails in general form, but the bill is somewhat compressed. The toes are so deeply divided, as scarcely to exhibit a vestige of the usual intervening membrane, and the hind toe is wanting. The species are of small size, and occur in India, Africa, and New Holland. They are of polygamous habits, and dwell in barren places on the confines of deserts, seldom taking wing except when closely run. One of these birds is also much used by the Malays and other eastern nations for fighting with its kind. (See Plate CCCXCVIII. fig. 9.)

A bird of a very anomalous aspect and character, called the heteroclyte grouse (*Tetrao paradoxus* of Pallas), now forms the genus Syrrhaptes of Illiger. The bill is rather slender and compressed, straight, but as usual somewhat bent towards the tip. The tarsi are short and densely clothed with feathers; the toes are also very short and feathered, and connected together almost to the claws. The hind toe is not wanting, but seems buried in the feathers. The wings and tail are very long, and are both terminated by lengthened slender-pointed plumes. The only known species (named *S. Pallasii* by M. Temminck), inhabits the deserts of Tartary, near the shores of Lake Baikal. Owing to the peculiar structure of its feet, it can scarcely move upon the ground; but its flight is brisk and rapid, though seldom long sustained.

The last group we shall here mention contains the *Tinamous*—genus Tinamus, Lath.,—*Crypturus*, Illig. (Plate CCCXCVIII. fig. 8.) The bill is lengthened and slender, slightly arched, blunt-pointed, grooved on each side, the nostrils central, deepening obliquely backwards. The wings are short, the tail almost rudimentary. The palmation at the base of the toes is very short; and the hind toe, reduced almost to a little spur, does not reach the ground. The bare space around the eye is very circumscribed. These birds abound in the Brazilian and other tropical forests of America, where they run swiftly, seldom fly, conceal themselves among long herbage, and perch (as some say) upon the lower branches of trees. They live on fruits and insects, and their flesh is much esteemed. Rather than exercise their natural powers of flight, they will sometimes foolishly allow themselves to be killed in great numbers with a stick. They are also hunted with dogs. They build upon the ground, and their eggs are remarkable among those of gallinaceous birds for their brilliant tinting, some being bright blue, others of a brilliant violet colour. The different species of Tinamous exhibit a great diversity in size, from that of a pheasant to a very small quail; and "as for their flesh," says Mr Swainson, "we have often tasted it, and consider it, both in whiteness and flavour, infinitely above that of the partridge or pheasant. We believe these birds never perch, as some suppose, but that they live entirely among herbage, principally in the more open tracts of the interior."[1]

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The great family of the pigeons (Columba, Linn.) comes next in order in Baron Cuvier's arrangement, and in that indeed of most of our systematic writers. There are several circumstances, however, which make it doubtful whether the pigeons should not form either a separate order of themselves, or undergo some other change in their position. As compared with ordinary gallinaceous birds, every one will admit that they present numerous and striking disparities. Their powers of flight, for example, if equalled are not surpassed even by those of the falcon tribe, their habits are monogamous, their haunts very generally arboreal, their eggs few in number, and hatched by the male as well as female, the young are at first extremely helpless, and are fed for a length of time from the crop of both parents,—in all these points, and many more, they differ remarkably from other gallinaceous birds. Professor Savi, we observe, places the pigeons in his concluding tribe of Passeres (*Uccelli silvani*), as a connecting link with the gallinaceous order, and for reasons closely corresponding with those we have just assigned.[2] Mr Macgillivray has recently observed, that "the beautiful, very extensive, and generally distributed family of birds commonly known by the names of pigeons, doves, and turtle-doves, appears to form an order of itself, separated by well-defined limits; but yet, as in other cases, presenting modifications of form indicative of its affinity to conterminous groups. The peculiar shape of the head and bill, more than any other external feature, serves to render the different species readily cognizable as belonging to a single tribe; for, whatever may be the size, colour, or even shape, of a pigeon, it cannot be mistaken. But the relations of the family, it would appear, are not so readily perceived,—some of our most approved systematists having associated them with the passerine, others with the gallinaceous birds,—while a few consider them as constituting a distinct group. Linnæus included them all under the single genus Columba, which has merely been sectioned by M. Temminck, and from which M. Vieillot has only separated two genera under the names of Treron and Lophyrus; while Mr Swainson and other Ornithologists have converted it into several generic groups, such as Vinago, including the thick-billed species, Ptilonopus, Columba, Turtur, Ectopistes, Peristera, and others, characterized by differences in the wings and tail; and Lophyrus, formed, by Vieillot, of the great crowned-pigeon. The latter seems to connect this family with the Cracinæ, which belong to the gallinaceous order, while other groups manifest an affinity to the partridges and allied genera. The pigeons vary much in form, some having the body full, others slender; while the tail is very short, moderate, or greatly elongated. In all, however, the head is small, oblong, compressed, with the forehead rounded; a circumstance depending partly upon the form of the skull, and partly upon the absence of feathers at the base of the bill. The latter organ is characterized more especially by having the nasal membrane bare, generally scurfy, fleshy, and tumid, with the narrow longitudinal nostrils placed under its anterior margin. It varies in size, but the upper mandible has its ridge always obliterated at the base by the encroachment of the nasal membranes, and its extre-

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[1] *Nat. Hist. and Class. of Birds*, vol. ii. p. 168.

[2] "Questa tribù forma il passagio dai Silvani ai Gallinacei, giacchè i Piccioni, quantunque somigliano più ai primi che ai secundi, pure han caratteri comuni agli uni ed agli altri. Somigliano i Silvani, perchè avendo ali grandi e coda larga, volano facilmente, con velocità, ed a grandi distanze; sono monogami: nascono nudi, e per un tempo assai lungo (almeno per tutte le specie nostrali) non essendo capaci nè di moversi, nè di cercare il cibo, han bisogno d'esser covati, e imbeccati da' loro genitori: fanno il nido sugli alberi, o nelle buche. Somigliano poi i Gallinacei per avere un gozzo molto dilatabile, e dove gli alimenti si trattengono e provano una certa preparazione alla digestione: i semi, di cui quasi esclusivamente si cibano, li inghiottono senza sbucciarli, o romperli, e finalmente, come i Gallinacei, hanno lo sterno doppiamente scavato." (*Ornitologia Toscana*, tom. ii. p. 152.)

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mity horny, arched, or convex, more or less compressed, with a blunt thin-edged point. The tongue is fleshy, tapering to a point, and triangular in its transverse section. The throat is very narrow. The œsophagus is of moderate width, but expanded, or opening into a large crop, placed on the lower part of the neck and the fore part of the breast, and terminates below in an oblong proventriculus, completely surrounded with large oblong glandules. The stomach is a powerful gizzard of a somewhat rhomboidal form, and furnished with two very thick lateral muscles inserted into two tendinous centres, with an inferior thinner muscle inserted into the same tendons. The intestine is long and slender; the cæca very small and cylindrical; the rectum very short, and but slightly enlarged. The tarsi are generally short and stout, either scutellate or feathered. The foot is of that kind equally adapted for walking and perching, having three toes before and one behind; the middle toe considerably longer than the two lateral, which are nearly equal, and the hind toe directed backwards, and shorter than the lateral. They are covered above with numerous short scutella, laterally margined, beneath flat and papillate. The claws are short, compressed, moderately arched, rather blunt. The plumage is various, so that no general character can be derived from it, farther than that the feathers have the tube very short, the shaft commonly thick, and are entirely destitute of the accessory plumule, which is largely developed in the gallinaceous birds. The wings are for the most part large, more or less pointed, with the second, third, and fourth quills longest; but the primary quills vary in form, and present several very curious modifications. The tail is even, rounded, cuneate, or graduated."[1] The skeleton, Mr Macgillivray further remarks, differs very materially from that of gallinaceous birds, and the intestine is much longer, the difference, however, in the other Gallinæ being made up by the great development of the cæca, which in pigeons are merely rudimentary, that is, extremely small, and secreting only a mucous fluid. We may add the following important character, that the hind toe is articulated on the same plane with the three anterior ones, instead of being placed higher up, as in the rest of the gallinaceous order. Although their legs are short, pigeons walk with great ease and considerable celerity.

These beautiful birds abound in most of the temperate and tropical regions of the earth, being, however, both more numerous and more gorgeously attired in the latter, where they often rival even the tribe of parrots in the splendour of their plumage, and literally realize the delightful expressions of the Holy Scripture—"as the wings of a dove covered with silver, and her feathers with yellow gold." The old genus Columba is one of the most cosmopolite with which we are acquainted, being found diffused alike through Europe, Asia, Africa, and America; and even in the forests of the far-distant Southern Ocean, their radiant plumage

> Fills many a dark obscure recess
> With lustre of a saintly show.

In no tribe of the feathered race do we meet with more to delight the eye by its richness and diversity. "In some," says Mr Selby, "the plumage shines with a dazzling and metallic gloss, varying in tint with every motion of the bird, and which vies in lustre with that of the diminutive and sparkling humming-birds. In texture the plumage is generally close and adpressed, and the feathers feel hard and firm to the touch, from the thickness and strength of the rachis or shaft. Upon the neck they assume a variety of forms, in some species being rounded and stiff, and disposed in a scale-like fashion; in others of an open, disunited texture, or with the tips divided and curiously notched; and in the hackled and Nicobar pigeons they are long, acuminate, and laciniated, like those of the domestic cock; and, we may add, that in nearly all they are so constituted as to reflect prismatic colours when held at various angles to the light."[2]

The vast variety of species and numerous sub-genera of which the *Columbidæ* are now composed render a full exposition impossible. We must, indeed, rest satisfied with a very brief notice of a few remarkable kinds. We have four species of pigeon in Britain, and we are not aware that more occur in Europe.

1*st*, The ring-dove, cushat, or wood-pigeon, *C. palumbus*, Linn., a large, beautiful, and well-known species, very generally distributed over the more or less wooded districts of our island, but avoiding bare and rocky regions. It breeds on trees in single isolated pairs, but is often gregarious to a great extent in winter. It is a wary bird, of powerful wing, not easily approached even in the forest glades, yet not seldom building in groves or groups of trees in the immediate vicinity of human dwellings; and we have seen a gentle pair sitting for hours upon the branches of an almost leafless sycamore in early spring, preening their feathers in assured confidence, within a few footsteps of our cottage door. Indeed we have often noticed, as others must have also done, what may be called the *discrimination* of birds, in relation both to persons and to places. We allude to what we should call their accommodating rather than their natural instincts,—how, for example, after a season or two of observation or experience, they will congregate around a spot where no rude hands disturb their mossy dwellings, nor climbing urchin shows his visage grim among the umbrageous boughs. This is beautifully exemplified (and on a greater scale than in a cottage garden) among the gladsome palace-groves of the Tuileries and Luxembourg in Paris, where, notwithstanding the gay and giddy stream of human life which flows for ever through those royal walks, the wood-pigeon builds her frequent nest, though far her flight to rural solitudes for every offering which she brings her much-loved young. This species generally breeds twice a year.

2*dly*, The rock or wild pigeon, *C. livia*, Briss., a smaller species, totally regardless of all the leafy glories of the forest, but loving devotedly the craggy cliffs and hollow caverns by the ocean-shore. This species is believed to be the original of our common domestic breed, of which the numerous and extraordinary, yet, with proper care, permanent varieties, are among the more puzzling problems of Ornithology.[3]

3*d*, The smaller wood-pigeon, erroneously called the stock-dove, *C. ænas*, Linn. This bird is much more limited in its distribution than either of the preceding, being as yet unknown in Scotland, and frequenting chiefly the southern and midland counties of the sister kingdom. It is almost entirely confined to wooded districts, its habits, according to Mr Selby, being strictly arboreal; yet Mr Salmon records it as abounding in heaths and rabbit warrens in the neighbourhood of Thetford, to which it annually resorts for the purpose of nidification.[4]

4*th*, The turtle-dove, *C. turtur*, Linn., a small and delicate species, unknown in "bleak Caledonia," but a constant summer bird in Kent, and other counties of the south of

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[1] *British Birds*, vol. i. p. 249.

[2] *Naturalist's Library*, vol. v. p. 88.

[3] For the domestic breeds, see Temminck's *Hist. Nat. Gén. des Pigeons et des Gallinacées*, MM. Boitard and Corbie's *Monographies des Pigeons Domestiques*, the *Pigeon Fancier*, and other works.

[4] *Magazine of Natural History*, vol. ix. p. 520.

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England, where it breeds in woods. It is sometimes seen towards the end of summer in little flocks of a score or two together. This bird leaves Britain in the course of the autumn, and does not to our knowledge remain in any part of Europe throughout the winter season.

Of the exotic pigeons one of the most remarkable is the goura, or great-crowned pigeon, *Lophyrus coronatus*, Vieillot (see Plate CCCXCIX. fig. 1). It is by far the largest of the tribe, measuring nearly two feet and a half in length. It inhabits Java, New Guinea, and most of the Molucca Islands, and is occasionally brought alive to Europe, where, however, the climate is too moist and variable to admit of its ever attaining to a good old age.

One of the most magnificent of the tribe is the hackled pigeon (*C. Franciæ*), distinguished by the irregular form of the feathers on the head, neck, and breast, which are long and narrow, and terminate in a shining appendage resembling in consistence, though not in colour, the tips of the wing-feathers of the waxen chatterer. It inhabits Southern Africa and the island of Madagascar. Another singular species is the parabolic pigeon (*C. arquatrix*), discovered by Vaillant, and figured in his splendid work on the birds of Africa. The flight of this bird is very remarkable. It never proceeds in a straight line, but on commencing its route describes a parabola, and continues forming a series of arcs during the whole time, frequently uttering a peculiar cry. It inhabits the forests of Anteniquois, and is so bold as to persecute the white eagle.

The carunculated pigeon (*C. carunculata*, Temm.) is placed by Mr Selby with the ground doves, genus GEOPHILUS of that author. This little group is not only distinguished by a greater length of tarsus and other organic characters, but by a striking departure from the general economy of the Columbidæ, the number of eggs not being confined to two, but extending to eight or ten. Incubation also takes place upon the ground; and the young, like those of the true gallinaceous birds, are produced from the egg in so matured a state as to follow their parents from the first. They live entirely on the ground, but roost at night on trees and bushes. The carunculated species just referred to is observed by M. Temminck to show a strong resemblance to the gallinaceous tribes both in aspect and manners. The fleshy scarlet lobes around the eyes and throat correspond, it is supposed, to the wattles of domestic poultry. It builds its nest in slight depressions on the ground, of twigs and stems of grass, and lays from six to eight eggs, which are sat upon alternately by male and female. The young are able to follow their parents as soon as hatched, and are led about by them, and brooded over with extended wings. Their first food consists chiefly of the larvæ of ants and other insects, and when greater strength is gained, of seeds and berries. The beautiful Nicobar pigeon (*C. Nicobarica*, Lath.) has been likewise referred to the same genus. Though of a heavy form and ungraceful carriage, it yields to none of its tribe in splendour of plumage, of which the prevailing hue is rich metallic green, with various reflections of copper and purplish red. It is generally described as residing habitually upon the ground, where it runs with great celerity,—perching on the lower limbs of trees at night. Yet Mr Bennet alludes to this species as usually seen perched on trees, even on the loftiest branches,—where, he adds, it rears its young "similar to all the pigeon tribe."[1] It inhabits Nicobar, Java, Sumatra, and other eastern islands.

We have already alluded briefly to the turtle-dove. The most common kind in cages, in this country, is not the English species, but that called the laughing or collared turtle, *T. risorius* (*torquatus*, Briss.). It is bred with great facility in Britain, but the winter cold would probably be too much for it out of doors; and it seems, moreover, to want that instinct of local attachment which induces our common pigeon to continue in the place where it was born and bred. In its natural state this species occurs in various parts of Africa.

Gralla-tores.

Somewhat resembling the turtles in the length of its wings and tail is the famous passenger pigeon of America, of whose rapid flight and countless congregations we have such graphic accounts in the delightful pages of Wilson and Audubon. This bird is the *Columba migratoria* of authors, and is placed by Mr Swainson in his genus ECTOPISTES. It may be presumed to be sufficiently common in North America, from a fact, or rather calculation, given by Alexander Wilson. He estimated a flock which continued to pass above him for the greater part of a day, to have been a mile in breadth, and 240 miles in length, and to have contained (three birds being assigned to every square yard), at least *two thousand two hundred and thirty million two hundred and seventy-two thousand pigeons!* Mr Audubon confirms his predecessor's account by a narrative still more extraordinary; and adds, that as every pigeon consumes fully half a pint of food (chiefly mast), the quantity necessary for supplying *his* flock must have amounted to *eight millions seven hundred and twelve thousand* bushels per day![2] We wonder, after this, that any farmer should ever dare to migrate to America.

The genus VINAGO of Cuvier consists of pigeons with strong solid compressed bills, short tarsi, and broad distinctly bordered feet. They inhabit forests, live on fruits and berries, and occur in the tropical regions of the old world. Their prevailing colours are various shades of green and yellow, contrasted with purple or reddish brown. The *Columba aromatica* of Latham is a Vinago. (See Plate CCCXCIX. fig. 3.)

We shall now close our brief sketch of the gallinaceous order.

ORDER V.—GRALLATORES.[3]

SHORE-BIRDS, OR WADERS.

The characters of this order, so far as they can be formally stated, are as follows. The shape of the bill is indeterminate. The legs are long and slender, and more or less bare above the tarsus. There are three anterior toes, more or less united at their bases by a membrane or rudimentary web. The hind toe is wanting in one division of the order.

Among the extensive and varied tribes which constitute the grallatorial order, the bill, as we have just intimated, is formed after so many different models (though always in beautiful accordance with the habits of each particular group), that its structure cannot be generalised, or sententiously expressed. The structure of the feet and legs is also admirably adapted for the exercise of their peculiar habits of life, being so lengthened as to admit of the species wading to a considerable depth without wetting their feathers, and of running with great rapidity along the margins of lakes and rivers, or the sea's more sandy shores. It is to this length of limb that they owe the name of *Grallatores*, as if they went on stilts. The French title of *echassiers* is also derived from the resemblance which the legs bear to the *echasses*, so frequently used by the natives of the *landes* of Aquitaine. A too exclusive attention, however, to this character seems to have misled some modern naturalists, who have included several very remotely

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[1] *Wanderings*, &c. vol. ii. p. 64.

[2] See his interesting account of the passenger-pigeon, in *Ornithological Biography*, vol. i. p. 319–26.

[3] GRALLÆ, Linn.

Grallatores.

allied genera under one order. Indeed a considerable diversity of opinion exists as to what ought to form the component parts of the grallatorial order. By means of the flamingoes and others, they are closely allied to the natatorial or web-footed birds,—while a dismemberment, partly from the latter order, partly from the original Grallæ, has been advocated in favour of the Grebes, Phalaropes, &c. as a separate and intermediate division under the name of *Pinnatipedes*.

The Grallatores seek their food in marshes, and along the banks of rivers and the shores of lakes. They also frequent the sea-coasts, where many kinds, especially in autumn, congregate in numerous flocks. But although the habits of the majority are *littoral*, many haunt habitually the arid deserts, the green and sedgy meadows, or the upland moors. Who knows not the plover's wailing cry among the desolate mountains,—the curlew's shrilly voice, "a viewless spirit of the elements," far up amid those scenes of pastoral melancholy, where the lonely rocks seem sometimes silent as gigantic spectres, and anon resound with varied and innumerable bleatings, as some gray-haired shepherd, "loving the land which once he gloried in," his dog his sole companion, gently leads along the fleecy people? In truth we often seek in vain to generalise the habits of the feathered race. In our systems we can give them both a local habitation and a name, but in nature they have wings, and like the wind travel where'er they please, and no philosopher either from field or college can say from whence they come, or whither they are going. The food of our present order varies according to the form of the mandibles. Such species as are provided with a long, hard, sharp-pointed bill, as in the heron tribe, live on fish and reptiles; the species in which that organ is softer and more flexible feed on worms and insects, whilst a more limited number, for example the land-rail (*Rallus crex*). are partly granivorous, and consequently affect a drier soil. The jacana (*P. chavaria*) is said to feed on grass. The habits of many species are migratory; and it has been remarked, that the young and old birds always perform their journeys in separate assemblages. A great proportion of the order congregates in the southern countries of Europe before the arrival of winter,—a season which many of them are supposed to spend in Africa. A few are winter birds of passage, that is to say, the temperate countries of Europe form their southern boundary, and during the breeding season they seek the colder regions of the north. The woodcock breeds in Scandinavia, where the observant traveller may frequently see it, not as with us the harbinger of storms, but darting across his dappled dusty path "in the leafy month of June." However, in several parts of the north of Scotland, woodcocks are now very frequent throughout the summer season, rearing their absurd-looking, long-billed progeny along the banks of the Dee, or in the well-wooded valleys of the eastern parts of Ross-shire. The smaller species, such as rails and sandpipers, run with great celerity; the paces of the larger kinds are more measured and sedate. During flight the legs in many kinds are extended on a line with the body. In some entire genera, and in certain species of other genera, the moult is double, that is, takes place both in spring and autumn, and occasions a great disparity between the plumage of the winter and summer seasons. The attire of the sexes is for the most part not very dissimilar. An apparent non-conformity may be said to exist in a few of the species, between the structure of the feet and the functions of these organs, which would disenable us from indicating, *a priori*, the habits of such species merely from an inspection of their organization. For example, the waterhen (*Fulica chloropus*) is an excellent and constant swimmer, and much more strictly aquatic than the avocet or flamingo, yet its toes are long and deeply divided, and furnished with an extremely narrow rudimentary web, while the last-named species, though semi-palmated, never voluntarily venture beyond their depth.

Grallatores.

The migratory movements of the Grallatores are probably determined in a great measure by the necessity of obtaining suitable nourishment. The rigour of a Scandinavian winter, which entirely congeals the surface of the moist forest-lands of Sweden and the swamps of Lapland, drives the woodcock to seek its food in the comparatively milder copses of Britain and Ireland; while the landrail, which is with us a native or summer bird, migrates in autumn to more southern regions, where it is probably known only as a winter visitant. Analogous facts have been observed in various parts of the world. Thus in regard to North America, the Grallatores, feeding by preference in marshy and undrained lands, frequent the Saskatchewan prairies only in the spring; and as soon as the warm and comparatively early summer has rendered the soil too dry for their accustomed purposes, they retire to their breeding places within the arctic circle. "There," says Dr Richardson, "the frozen sub-soil, acted upon by the rays of a sun constantly above the horizon, keeps the surface wet and spongy during the two short summer months, which suffice these birds for rearing their young. This office performed, they depart to the southward, and halt in the autumn on the flat shores of Hudson's Bay, which, owing to the accumulations of ice drifted into the bay from the northward, are kept in a low temperature all the summer, and are not thawed to the same extent with the more interior arctic lands before the beginning of autumn. They quit their haunts on the setting in of the September frosts, and passing along the coasts of the United States, retire within the tropics in the winter."[1]

The majority of the Grallatores are swift and powerful flyers, being provided with rather long, acutely-pointed wings; but to these attributes we have a few strong and singular exceptions in such birds as the ostriches and cassuaries, which have scarcely any wings, and cannot fly at all.

Baron Cuvier has established the five following tribes among the Grallatores, viz. Brevipennes, Pressirostres, Cultrirostres, Longirostres, Macrodactyles.

Tribe 1st.—Brevipennes.

The small number of gigantic birds which constitute our present tribe differ greatly, not only from the other Grallæ, but from all known species; 1*st*, in the extreme shortness of their wings, which, though no doubt useful in their way, are altogether destitute of power to raise their bodies from the earth; and, 2*dly*, in the sternum or breast-bone being destitute of a ridge or keel. The muscles of the breast are also extremely slight and thin. "Il paraît," says Cuvier, "que les forces musculaires, dont la nature dispose, auraient été insuffisantes pour mouvoir des ailes aussi étendues que la masse de ces oiseaux les aurait exigées pour se soutenir en l'air."[2] This is not expressed according to the English mode of thought and feeling, but it may pass for what it means. To make amends, however, for this supposed incapacity of nature, we find that the muscles of the legs have received an enormous development, which enables the species to run almost with the rapidity of race-horses, and to be thus independent of aërial flight. In some of our modern systems these birds form the family *Struthionidæ*, and are placed in the gallinaceous order.

In the genus Struthio, which contains the true ostrich,

[1] *Fauna Boreali-Americana*, part ii. Introduc. p. xix.

[2] *Règne Animal*, tom. i. p. 494.

Grallatores.

the wings are adorned by loose flexible plumes, and though of small extent, are still sufficient to afford effectual aid in running. The toes, at least externally, are only two in number.

The only known species is the ostrich commonly so called (*Struthio camelus*, Linn., Plate CCCXCIX. fig. 5), a bird which forms one of the most remarkable characters in the Ornithology of Africa, to which country it is believed to be almost entirely peculiar. It presents the tallest, and in many other respects the most singular example of the feathered race. It measures from six to seven feet in height; its head is very flat, extremely small, and almost naked; as is also the upper portion of the neck, which is very slender, and nearly three feet long. The general plumage of the male is black, varied with white and gray, the fine full feathers of the wings and tail being either black or white. Our engraving will best explain its outer aspect. The female is brown or ashy-gray upon the body; the young are likewise of the latter hue, and have at first the head and neck densely clothed. The ostrich inhabits the deserts of Arabia, and a vast extent of open sandy plains in Africa, from Barbary to the Cape of Good Hope. Being consequently native to one of the most anciently peopled countries of the earth, it has excited the attention of mankind from the remotest periods of antiquity. It is frequently mentioned in the book of Job, and in other portions of the Old Testament. Herodotus among the early Greek writers was well acquainted with its history and appearance, and in after times it was not only frequently exhibited by the Romans in their games, but the brains of hundreds at a time were scooped out as a choice delicacy for the luxurious table of Heliogabalus.

The ostrich is gregarious and polygamous. The female deposits her eggs, weighing nearly three pounds, in the sand. These, in equatorial regions, are hatched by the heat of the sun, with little or no attention on the part of the mother; but on either side of the tropics are said to be incubated in the usual fashion. This gigantic bird feeds naturally on seeds and herbage; but its taste is so obtuse, and its swallowing propensities so universal, that there are few substances, however incongruous or indigestible, which it declines. It is said by some to be the swiftest of all running creatures, and Adanson seemed satisfied that those he saw at Podor, a French factory on the southern side of the Niger, would have distanced the fleetest race-horse that was ever bred in England. There is no doubt that the peculiar construction of birds, in relation both to the respiratory and circulating systems, is such as to admit of their keeping in much better *wind* than is possible for any quadruped; and when, as in the case of the species in question, great muscular power is superadded, the natural result must be prodigious swiftness.

The nandou or American ostrich now forms the genus Rhea, of which it is the sole species, characterized by having three toes, the wings terminated by a little spur, and the tail wanting. It is not above half the size of an ostrich, of a whitish-gray, lead coloured on the back, the head covered with close-set blackish feathers, almost as stiff as hair. This bird inhabits the pampas of Paraguay, in troops of a few dozen, and extends almost as far south as the Straits of Magellan. It is a gentle, innocent creature, of herbivorous habits, easily tamed if taken young, and laying an enormous number of eggs. As several females sometimes sit together, it is probable that the number of seventy or eighty eggs, alleged to have been found in a single nest, are not the produce of one bird, but rather the result of a kind of joint-stock incubating company. Its flesh is eaten by the Indians, and its feathers, from their peculiar structure, make very good hair-brooms.

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In the genus Casuarius, the wings are still shorter than in either of the preceding, and seem of no use even in running. They consist, in fact, merely of a few hard, stiff, sharp-pointed, barbless shafts. The head is surmounted by a bony crest, and the bill is laterally compressed (see Plate CCCXCIX. fig. 2). The sole species is the common cassuary (*C. galeatus*, Vieil.), a bird first imported to Europe by the Dutch in 1597. Like the rest of its tribe, it is extremely large, measuring about five feet in height. Its plumage is very peculiar, being long, narrow, decomposed, and hair-like, and the *plumule*, or short inner feather (which exists in almost all birds except pigeons), is of nearly equal length with the outer portion, so that an appearance is produced of there being a double feather to each quill. The prevailing colour is blackish. The cassuary inhabits the Moluccas, Ceram, Bourou, and especially New Guinea. These birds usually live in pairs, and the female lays three eggs, of a greenish hue, and punctured surface. They run with great swiftness, and defend themselves from dogs and other animals, by kicking like horses. The inner claw is very large and strong.

The emeu, or New Holland cassuary, forms the genus Dromecius of Vieillot. The bill is much depressed, the head feathered, without osseous crest, the throat naked. The claws are of nearly equal length. The general colour is dull brown mottled with dingy gray; the young are striped with black. The plumule is equally extended as in the preceding species. (See Plate CCCXCIX. fig. 6.) Next to the ostrich, the emeu is the tallest bird we know. Its flesh affords admirable eating,—"truly exquisite," says Peron, "and intermediate, as it were, between that of a turkey and a sucking pig." Mr Cunningham compares it to beef, which is also an excellent thing. This bird is widely spread over the southern parts of New Holland and the adjacent islands. It is tamed with great ease, and of late years has frequently bred in Britain.

In the genus Apteryx of Shaw,[1] the bill is slender and of considerable length, the legs short, with three anterior toes, and a posterior spur to represent the hallux. The wings are rudimentary. The only known species was obtained a good many years ago on the south coast of New Zealand, by Captain Barclay of the ship Providence, and was presented by him to Dr Shaw. It equals a goose in size. This bird, of which the history was long obscure, has been recently received in London.[2]

The last ornithological form to which we shall allude under our present tribe is the mysterious Dodo (*Didus ineptus*), a bird which some regard as an extinct, others as a fabulous, species. In neither supposition would it fall within the limits of our present treatise, which seeks to present a sketch, however imperfect, of living nature; and we shall therefore not occupy our narrow limits by a subject of "doubtful disputation," on which we cannot ourselves throw any light, having neither been in the Mauritius, nor studied the works of Clusius and the early Dutch navigators.[3]

Tribe 2d.—Pressirostres.

This tribe consists of the bustards, plovers, and other species which, like all the preceding, either want the hind toe, or have it so short as not to touch the ground. The bill is of medium size, but of sufficient strength to pierce the ground in search of worms and insects, the feebler

[1] *Naturalist's Miscellany*, pl. 1057–8.

[2] Yarrell, in *Zool. Trans.* i. pl. 10.

[3] Whoever desires it, will find a summary view of authorities regarding the dodo, by Mr T. S. Duncan, in the *Zoological Journal*, No. xii. p. 554

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species often frequenting moist meadows and tilled ground in search of food. The stronger billed kinds feed also on grain, &c.

The genus Otis, Linn., possesses the bulky massive form of the gallinaceous order, and the upper mandible is somewhat arched; but the bare space above the tarsus, the want of the hind toe, and the general structure both outward and internal, connect them more closely with the Grallatores. The great bustard (*Otis tarda*) is the largest of the European birds, and one of the rarest of our British species. It sometimes weighs nearly thirty pounds, and is now believed to be confined exclusively to Norfolk. We have another species called the little bustard (*O. tetrax*), also very rare. Many fine species occur in Africa and the East. (See Plate CCCXCIX. fig. 4.)

The genus Charadrius, Linn., likewise wants the hind toe. The bill is compressed, and somewhat enlarged towards the tip. It contains the various species commonly called plovers, and may be divided into two. 1*st*, Œdicnemus, Temm., in which there is an inflation towards the terminal portion of the bill in both mandibles, and the nasal fossæ are less prolonged. These are the larger species, of which the great plover (*Œdic. crepitans*), or thick-knee'd bustard of our English writers, affords a good example. It is a migratory bird, of rare occurrence, confined chiefly to our southern and eastern counties, which it visits about the end of April. It is as yet unknown in Scotland. This bird is a nocturnal feeder, and preys principally upon insects. 2*d*, Charadrius, in which the bill is inflated only above, and two thirds of its length on each side are occupied by the nasal fossæ, which renders the organ comparatively feeble. The species are gregarious, and, like the gulls, beat the moist soil with their pattering feet, to terrify the incumbent worms. "The members of this genus," says Mr Selby, "are numerous, and possess a very wide geographical distribution, species being found in every quarter of the globe. Some of them, during the greater part of the year, are the inhabitants of open districts and of wild wastes, frequenting both dry and moist situations, and only retire towards the coast during the severity of winter. Others are constantly resident upon the banks or about the mouths of rivers, particularly where the shore consists of small gravel or shingle; such are most of the smaller species. Except during the season of reproduction, most of them live in societies, larger or of less amount, according to the species. Their migrations are also performed in numerous bodies, the old birds usually congregating by themselves, and preceding the young in their periodical flights. They run with much swiftness, as might be expected from the simple structure of their feet; and from the shape and dimensions of their wings, they fly with strength and rapidity. They live on worms, insects, and their larvæ, &c. and most of them are nocturnal feeders, as indicated by their large and prominent eyes. They are subject to the double moult, and the change at the different seasons is in many species very marked. Their nest is on the ground, and their eggs are always four in number. The flesh of the larger species, and such as inhabit the plains of the interior, is delicate and high flavoured; but in many of the smaller kinds, that live on the coast, or on the banks of rivers, it is not so palatable."[1] The beautiful golden plover (*Char. pluvialis*) is the best-known example to which we need refer. The prevailing plumage of the upper parts is brownish, or very deep hair-brown, each feather being tipped and otherwise spotted with yellow. The chin and throat are white, the fore part of the neck, breast, &c. ash-gray, streaked with darker gray, and tinged with yellow. During the breeding season, the cheeks, chin, throat, fore part of the neck, centre of the breast, and abdomen, are of an intense black, and in this state it has been erroneously regarded as a distinct species. To the same group belong the dotterel (*Char. morinellus*), the ring-plover (*Char. hiaticula*), and many other kinds, exotic and indigenous. Several of the foreign plovers have sharp spurs upon the anterior margin of the wing, as well as fleshy flattened lobes upon the head.

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The genus Vanellus of Bechstein differs but little from the plovers, except in the possession of a small hind toe. We here place our elegant crested lapwing, or green plover (*V. cristatus*), commonly called in Scotland the *pees-weep*. The gray plover (*C. squatarola*, Linn.) forms the genus Squatarola of Cuvier, distinguished, like the preceding, by a very small hind toe; but the bill is more bulged beneath towards the extremity, and the nasal fossæ are short.

The genus Hæmatopus, Linn., commonly known by the name of oyster-catcher, has the bill rather long, straight, pointed, compressed. The hind toe is wanting. Our British species (*H. ostralegus*), breeds along the rocky ledges of friths and bays, and is said to open oyster and other shells by means of its bill. We could never detect it in the performance of this feat, and we rather doubt the fact, till assured of it by a credible eye-witness. Oysters are by no means easily opened, even with a knife. Several nearly allied species have been discovered of late years in Asia, Africa, and America. One is found in New Holland.

In the genus Cursorius the bill is slender, rounded, somewhat arched, without furrow. The legs are long, the hind toe wanting. Five or six species occur in Africa and Asia, and of these, *C. Isabellinus*, Meyer, sometimes accidentally appears in the south of Europe. A few specimens have been even seen in Britain.

The genus Microdactylus, Geoffroy (*Dicholophus*, Illiger), has the bill stronger and more curved, with a wider gape. The legs are of great length, the toes slightly palmated at the base, the hinder one very small, and not reaching to the ground. The only known species is a singular South American bird called the *çariama* or crested screamer (*M. cristatus*, Geoff.,—*Palamedea cristata*, Gm.). It is larger than a heron, the plumage reddish gray waved with brown, the forehead ornamented by a crest of recurved slender feathers (see Plate CCCXCIX. fig. 8). The plumes of the head and neck are also decomposed. The çariama inhabits elevated plains in Brazil and Paraguay, where it feeds on serpents and other reptiles, as well as on insects and their larvæ. It flies feebly, owing to the shortness of its wings, but runs with considerable swiftness. When pursued, it is apt to conceal itself by squatting in some cunning corner. Its flesh affords excellent food, and it is sometimes reared by the Spaniards in a domestic state. The female lays only two eggs.

Tribe 3d.—Cultrirostres.

In this tribe the bill is usually strong, of considerable length, straight, cutting, sharp-pointed. In many species the trachea undergoes a peculiar duplication in the male sex. The cæca are short. Cuvier divides the tribe into three lesser groups,—the *cranes*, the *herons*, and the *storks*.

The cranes properly so called (genus Grus) have the bill longer than the head. The most noted species is the common crane of Europe (*G. cinerea*), a migratory bird,

[1] *British Ornithology*, vol. ii. p. 230.

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well known in Britain during former ages, and still breeding in the northern and eastern countries of Europe.

> Part loosely wing the region, part more wise,
> In common, ranged in figure, wing their way,
> Intelligent of seasons, and set forth
> Their airy caravan high over seas
> Flying, and over lands with mutual wing,
> Easing their flight; so steers the prudent crane
> Her annual voyage, borne on winds, the air
> Flotes as they pass, fann'd with unnumber'd plumes.

In our own island the appearance of this bird now-a-days may be regarded as accidental. It is a very large species, measuring above four feet in height. The prevailing plumage is of a deep ash-gray, the face and throat black, the rump and tertial feathers very long, loose, flowing, decomposed.

The whooping crane of the new world (*Grus Americana*) has a pure white plumage, with black primaries. (See Plate CCCC. fig. 1.) This stately bird, when standing erect, measures nearly five feet in height, and is the largest of the feathered inhabitants of the United States (bating Lynch law and the use of tar). It is widely spread over North America, from which it usually retires in winter to the West Indies, although a few hybernate in the warmer parts of the Union, or even linger throughout that inclement season in the swamps of New Jersey, near Cape May. When wounded this crane defends itself with vigour, and has been known to strike its bill through a person's hand with the strength and sharpness of a dagger. It builds upon the ground, and sometimes congregates in vast flocks, the clamour of which is more easily imagined than described. It was heard with astonishment by Captain Amidas, the first Englishman who ever landed in North America, when he visited the island of Wokokou, off the coast of North Carolina. "Such a flock of cranes," says he, "(the most part white) arose under us, with such a cry, redoubled by many echoes, as if an army of men had shouted all together." The bustle of their great migrations, and their passage, as of mighty armies, fill the mind with wonder. Mr Nuttall, while descending the Mississippi in December, observed the whooping cranes in countless thousands, as if assembled from all the swamps and marshes of the north and west,—as if the entire continent was giving up its quota to swell the mighty host. Their flight took place during the night, down the great aërial valley of the river, whose southern course conducted them every instant towards more genial climes. "The clangour of these numerous legions passing along, high in the air, seemed almost deafening; the confused cry of the vast army continued with the lengthened procession, and as the vocal call continued nearly throughout the whole night without intermission, some idea may be formed of the immensity of the numbers now assembled on their annual journey to the regions of the south." Several other fine cranes inhabit America, as well as Africa, and the East.

The beautiful Balearic crane (*A. pavonina*, Linn.) belongs to the genus Anthropoides of Vieillot. (Plate CCCXCIX. fig. 9.) It occurs in Africa and in some of the Mediterranean islands. The *Demoiselle* (*A. virgo*), remarkable for its peculiar and what may be almost called *affected* gestures, is nearly allied. It is likewise of African origin, as is also the Stanley crane (*Anth. Stanleyanus*), belonging to the same restricted group, and more recently described by Mr Vigors.[1]

In the genus Psophia, which contains the South American trumpeters, so called from their peculiar voices, the bill is less elongated, and the head and neck clothed with short down-like feathers. *P. crepitans* is easily domesticated, and becomes much attached both to places and to persons. It is even said to act as a guard or conductor to domestic poultry. It flies indifferently, but runs with great swiftness. (Plate CCCXCIX. fig. 7.) There are only two species.

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The genus Aramus of Vieillot is constituted by the *courliri* of Buffon, or scolopaceous heron, of which the bill, slenderer and more deeply cleft, is inflated towards the tip. The toes, all rather long, have no palmation. The only known species (*Ar. scolopaceus*) inhabits Cayenne, Brazil, and Paraguay, spreading into Florida and other southern parts of the Union. It is a shy and solitary bird, dwelling in pairs, and crying in a loud sonorous voice, continually by night and day, *carau, carau*. It runs swiftly, and builds upon the ground, but often lights on trees. It is not fond of wading.

A still more singular bird, classed by Linnæus with the herons (*Ardea helias*), is the caurale snipe of Latham, which now forms the genus Eurypyga of Illiger. "C'est un oiseau," says Cuvier, "de la taille d'un perdrix, à qui son cou long et menu, sa queue large et étalée, et ses jambes peu élevées, donnent un air tout différent de celui des autres oiseaux de rivage. Son plumage, nuancé par bandes et par lignes, de brun, de fauve, de roux, de gris, et de noir, rappelle les plus beaux papillons de nuit. On le trouve le long des rivières de la Guiane."[2]

The second group of the cultrirostral tribe, composed chiefly of the herons, is more strictly carnivorous than the preceding.

The first genus is Cancroma, Linn., composed likewise of a single species called the boat-bill—*C. cochlearia*. The bill is comparatively short, but very broad, boat-shaped, with the upper mandible overlapping the lower. It inhabits the moist hot regions of South America, frequenting the banks of rivers, preying on fish, and building its nest on low bushes. It is of an irritable passionate nature, and when enraged raises the feathers of its crest, so as to alter its usual aspect surprisingly. As it scarcely ever frequents the sea-coast, its alleged propensity to feed on crabs is probably ill founded. The boat-bill varies considerably in plumage, but it does not appear that there is more than one authentic species.

The genus Ardea, Cuv., contains the true herons. The bill is as long or longer than the head, strong, hard, straight, compressed, sharp-pointed; the masticating edges sharp, the culmen rounded. The eyes are encircled by a bare skin, which extends to the base of the bill. The herons form a considerable group, almost all of which, according at least to our particular taste, are remarkable for beauty of plumage. They seldom, however, exhibit a preponderance of the brighter or more gaudy colours, such as red or yellow, being chiefly distinguished by a delicate harmonious blending of pearly-gray and brown, black, white, pale blue, slate-colour, and other sober hues. The *forms* of the plumage are graceful and elegant. Long pendent plumes frequently ornament the hinder portions of the head and neck, the lower part of the breast, and the dorsal region. The body is usually small and light, the limbs long and delicate, the toes narrow and taper, and the neck thin, pliant, and extremely graceful. Many species formerly regarded as true herons are now excluded from the modern genus. The habits of the heron tribe are fully as aquatic as those of the majority of Grallatores. They usually walk, or rather wade, along the shores of lakes, rivers, stagnant marshes, or the land-locked waters of narrow seas, in search of their natural food, which consists of fish, frogs, several marine and fresh-water shells, slugs, worms, and various insects. During flight they extend their legs backwards instinctively, as if to counterbalance the weight of the anterior extremity, and by a duplication of the neck they lower the head between the shoulders. In some instances

[1] *Zool. Journal*, vol. ii. p. 234, pl. viii.

[2] *Règne Animal*, tom. i. p. 509.

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they are gregarious, in others solitary. In the former case they build in trees,—in the latter, more frequently among reeds or rushes. Several species afford an excellent though now much-neglected article of food, and were not only prized as such in England in the olden time, but were objects of still higher interest and regard, as affording the finest display of strength and intrepidity in the practice of the noble art of falconry. Birds of this genus occur in almost every quarter of the known world. The species which inhabit high northern latitudes, such as Kamtschatka and the shores of Hudson's Bay, migrate southwards before the arrival of winter. Such as breed in warm or temperate climates are more stationary.

Our common or long-necked heron (*Ardea major et cinerea*, Linn.) affords a familiar example of the genus. "Yon Cassius hath a lean and hungry look," yet when examined close at hand he is an elegant and beautifully plumaged species. The heron usually builds on the tops of lofty and umbrageous trees, yet in an island of Loch Conn we have seen its nest on *pollards* not more than ten feet high; and we lately noticed a large heronry among the precipitous cliffs which overhang the sea about a mile outside the entrance to the Cromarty Frith, upon the northern shore. We have several other British herons, the majority of which, however, must be regarded rather as stragglers or accidental visitors, than as truly indigenous species. The egrets are beautiful crested herons, with the plumage usually pure white, and in part decomposed, or very loose and flowing. Of these, the little egret (*Ardea garzetta*, Linn.) is common in Turkey, and the east of Europe, as well as in many parts of Asia, Africa, and the islands of the Mediterranean. It is frequently alluded to in the ancient household books of England; and in the recorded bill of fare of the famous feast of Archbishop Neville, in the reign of Henry IV., a thousand are said to have been served up at a single entertainment. It is indeed extraordinary that a bird now so rare in all the western countries of Europe, should have been at any time so superabundant in Britain; and Dr Fleming has judiciously suggested that the lapwing, which is so beautifully crested, may have been indicated under the old title of *egritte*. The true egret is not even alluded to as an indigenous bird so far back as the time of Willughby and Ray. The great egret (*Ardea egretta*, Temm.) is well known in Poland and Hungary, but scarcely ever shows itself in the western parts of the European continent.

The bitterns have the plumage of the neck extremely full and elongated. Their colours are usually brownish yellow, radiated or spotted with black. They form the modern genus Botaurus. The night-herons constitute another generic group, under the title of Nycticorax. The term, which signifies night-raven, has been no doubt applied from the circumstance of their feeding at night, and remaining in a state of comparative rest and inactivity throughout the day. The European species (*Ardea nycticorax*, Linn.,—*Nyc. Europeus*, Stephens) is more common in America than in the old world. New Holland and Africa each possesses a species. In form, Sir William Jardine observes, these birds are intermediate to the bitterns and true herons; the bill is short, and stronger in proportion than in either, and the hind head is adorned with (generally three) narrow feathers in the form of a crest. They feed by twilight, or in clear nights, and take their prey by wary watching, like the herons. They are gregarious and build on trees, and are noisy and restless during the period of incubation. The prevailing colours are ash-gray and black, or pale fawn and chesnut. The young are always of a dingier hue than their parents, and have their feathers marked with whitish spots.

The remaining genera of the *Cultrirostres* form Cuvier's third group.

In the genus Ciconia, Cuv., the bill is large, without nasal groove or furrow, the nostrils pierced near the base, and towards the dorsal portion. The tarsi are reticulated, and the anterior toes strongly palmated, especially the external. The mandibles are broad and light, and when struck together produce a frequent and peculiar snapping sound, almost the only one they ever utter. The best-known European species is the white or common stork (*Ciconia alba*), a bird somewhat smaller than the crane, but larger than the heron. The bill and legs are red, the whole plumage pure white, except the greater coverts, scapulars, and quill-feathers, which are black. It is a common summer bird in several European countries, especially Holland, where it is esteemed and protected, and has become so familiar as to build on the tops of houses even in the centre of large towns. Its periodical migrations have long excited the admiration of naturalists by their extent and regularity. They are indeed beautifully and wisely directed. "Yea, the stork in the heavens knoweth her appointed times; and the turtle, and the crane, and the swallow, observe the time of their coming." The species appears to have been regarded with peculiar favour in almost all ages and countries. By the ancient Egyptians it was looked upon with a reverence only inferior to that which they paid to the mystical ibis; the same feeling still preponderates in many parts of Africa and the East; while nearer home the Dutch are remarkable for their affectionate attachment to this "household bird." On the other hand, the stork itself appears to reciprocate this friendly feeling. Undismayed by the presence of man, it builds its capacious nest upon the house-top, or on the summits of "ancestral trees" in the immediate vicinity of human dwellings, or even environed by the busiest haunts of men. "It stalks," says Mr Bennet, "perfectly at ease along the busy streets of the most crowded town, and seeks its food on the banks of rivers, or in fens in close vicinity to his abode. In numerous parts of Holland its nest, built on the chimney top, remains undisturbed for many succeeding years, and the owners constantly return with unerring sagacity to the well-known spot. The joy which they manifest in again taking possession of their deserted dwelling, and the attachment which they testify towards their benevolent hosts, are familiar in the mouths of every one. Their affection for their young is one of the most remarkable traits in their character. It is almost superfluous to repeat the history of the female which, at the conflagration of Delft, after repeated and unsuccessful attempts to carry off her young, chose rather to perish with them in the general ruin than to leave them to their fate; and there are many other and well-authenticated proofs of a similar disposition. They generally lay from two to four eggs, of a dingy yellowish white, rather longer than those of the goose, but not so broad. The incubation lasts for a month, the male sharing in the task during the absence of the female in search of food."[1]

Of the foreign species, the gigantic stork (*C. argala*) is well known in India by the name of adjutant. It measures upwards of six feet in height. A nearly allied species is the marabou of Africa (*C. marabou*, Temm.), very common in many parts of the interior. According to Major Denham, it is protected by the inhabitants on account of its services as a scavenger. Its appetite is most voracious, and nothing comes amiss to its omnivorous propensities. Mr Smeathman has given a long account of a bird of this kind which regularly attended at the dining table, and frequently helped itself to what it liked best. It one day darted its enormous bill into a boiled fowl, which it

[1] *Zoological Gardens*, ii. 21.

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swallowed so instantaneously that all hope of rescue was in vain. On another occasion it actually bolted a cat.

The genus MYCTERIA, Linn., contains the birds called *jabirus*. They scarcely differ from the storks, except in the bill exhibiting a slight curvature upwards. The species, if correctly referred to by naturalists, though few in number, inhabit widely distant regions,—*M. Americana* being native to Cayenne, *M. Australis* to New Holland, and *M. Senegalensis* to Western Africa. Is the latter synonymous with Dr Ruppell's saddle-billed stork, *C. ephippiorhyncha ?*

The genus SCOPUS is composed of a single species, *S. umbretta*, Linn., an African bird, of the manners of which we are still entirely ignorant. In English books it is called the tufted umber. Its generic title (Σκοπος) is Greek for sentinel. It is probably watchful and solitary.

The genus ANASTOMUS, of which the Pondicherry and Coromandel herons of Latham serve as examples, is peculiar to the East Indies. These species present a remarkable peculiarity in the structure of the bill. The mandibles touch each other only at their points and bases, thus leaving a gaping intervening space. *An. Coromandelianus* is common on the banks of the Ganges, and other eastern rivers, and likewise frequents the Coromandel coast during the months of September, October, and November, feeding on fish and reptiles. A more recently discovered species is *An. lamelligerus* of Temm. (*Pl. Col.* 236), a native of the Cape.

The genus DROMAS of Paykull has the bill compressed and swollen at the base beneath, with the commissures close. The only known species is *D. ardeola*, Temm. *Pl. Col.* 362, an African bird, with white plumage, the back and pinions, as well as the legs and bill, being black. It is of rare occurrence, but rather extended distribution, specimens having been obtained both from the shores of the Red Sea and the Senegal coast. "L'ardeole," says M. Lesson, "tient des œdicnèmes par son bec, et mêmes des sternes, de l'avocette, par son plumage et les tarses. C'est un véritable oiseaux de transition dans l'établissement des familles."[1] Some recent writers regard this bird as identical with the *corrira* so long ago described by Aldrovandi[2] as an Italian species, but not since seen either in Europe or elsewhere. The descriptions however do not accord. Bechstein, Vieillot, and others, think the Italian corrira a fictitious species, made up from the body of an avocet and the legs of a thick-knee'd plover; but Professor Ranzani is of opinion, that as its name is a vernacular one, and there is no proof that Aldrovandi possessed any stuffed birds (none being mentioned in the catalogue of his museum, and the art in those days being almost unknown), a well-known living species must have been alluded to. Indeed it appears that Charleton, at least seventy years after the printing of the Italian author's third volume, received a specimen from Merret of what he considered as the bird in question.[3] "Non vi ha al certo," observes Ranzani, "alcun giusto motivo di rivocare in dubbio, che al tempo di Aldrovandi si trovasse ne' luoghi vallivi del territorio Bolognese un uccello steganopodo, il quali venisse da' cacciatori chiamato corrira, perchè correva velocémente." "E quantunque," he afterwards adds, "oggidì niuno de' molti cacciatori Bolognesi da me consultati conosca la corrira, non cesserò io per questo dal farne le più diligenti ricerche, potendo benissimo accadere, ch'essa torni alcuna volta a visitare i nostri terreni vallivi."[4]

In the genus TANTALUS, Linn., the bill, nostrils, and feet resemble those of the storks, but the back of the upper mandible is rounded, its point curved a little downwards, and slightly notched on either side. A portion of the head, and sometimes of the neck, is bare of feathers. The species, formerly confounded with the ibises, are of large size, and inhabit Asia, Africa, and America. The best known is *Tantalus loculator*, called the wood ibis in the United States. It is white, with the face and head greenish blue, the quill and tail feathers black, with coloured reflections. It measures above three feet in length, and the bill itself is about nine inches long, very broad at the base. The wood ibis is a solitary indolent bird, seldom associating in flocks, but resting alone, like a feathered hermit, listlessly on the topmost limb of some tall decayed cypress, with his neck drawn in upon his shoulders, and his enormous bill resting like a scythe upon his breast. Thus pensive and lonely, he has a grave and melancholy aspect, as if ruminating in the deepest thought; and in this sad posture of gluttonous inactivity (for in truth he has only over-eaten himself) he passes much of his time, till aroused by the cravings of hunger. He feeds on snakes, young alligators, fish, frogs, and other reptiles, and wisely migrates southwards on the approach of winter.[5] In the United States the principal residence of this bird is in the inundated wilds of the peninsula of East Florida. The *Tantalus ibis* of Linn. is an African species, long erroneously regarded as the bird so highly venerated by the Egyptians; but it scarcely occurs in the country of the pyramids, being usually imported from Senegal. The other species of this genus are *T. leucocephalus*, from Ceylon and Bengal; and *T. lactea* (Temm. *Pl. Col.* 352), from Java.

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The last genus we shall mention of our present tribe is PLATALEA, Linn., containing the birds called spoon-bills, which, like the preceding, are also few in number. The chief character is constituted by the rounded flat enlargement or dilatation at the extremity of the bill, from which they derive their English name. They inhabit marshy and muddy places, where they grope about with their *spoons* in search of worms and mollusca. They are gregarious and migratory, build on trees, occasionally among rushes, and occur in Europe (*Pl. leucorodia*), Africa (*Pl. nudifrons*), and America (*Pl. ajaja*). The last-named species, called the roseate spoon-bill, is a beautiful bird, the ground-colour white, but richly tinged with rose-colour, deepening in part into carmine-red. The feet are half webbed, and the toes are very long (see Plate CCCC. fig. 2). This bird is more maritime in its habits than the European kind, and wades about the coast in quest of shell-fish and small crabs. According to Captain Henderson (in his account of Honduras), it occasionally both swims and dives. Although it now and then straggles up the Mississippi towards Natchez, into Alabama, and even as far north as the banks of the Delaware, it is a truly tropical bird, frequent in Jamaica and other islands of the West Indies, as well as in Mexico, Guiana, and Brazil. In a southerly direction, it is said to spread as far as Patagonia.

TRIBE 4TH.—LONGIROSTRES.

In this tribe the bill may be characterized as lengthened and feeble. The species belong chiefly to the old genera *Scolopax* and *Tringa* of Linn. They bear a general resemblance in their forms and habits, and frequent moist places, where their slender bills can probe for worms and insects, without the risk of fracture.

In the genus IBIS, Cuv., the bill is long, arched, broad, and squarish at the base, with the point depressed, obtuse, rounded, and the upper mandible deeply furrowed throughout its whole length. The nostrils are narrow and oblong,

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[1] *Traité d'Ornithologie*, p. 331.
[2] *Ornithologia*, t. iii. p. 288.
[3] *Exercitationes de differentiis Animalium*, Oxonii, 1677, p. 102–3.
[4] *Elementi di Zoologia*, t. iii. parte ix. p. 300–2.
[5] Nuttall's *Manual*, vol. ii. p. 83.

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and pierced through the membrane of the furrow near its base. The forehead and lores are bare of feathers.

The species of this remarkable genus are distributed over the warmer zones of all the four quarters of the globe, the green or glossy ibis (*Ibis falcinellus*), being itself found in Europe, Asia, Africa, and America, and occasionally in Great Britain. The sacred or Egyptian ibis (*Ibis religiosa*, Cuv.,—*Tantalus Ethiopicus*, Latham) is a bird of a more striking and peculiar aspect, though undistinguished by much diversity in the colours of its plumage. It measures about two feet six inches in length. The head and neck are, in the adults, bare of feathers, presenting nothing but a dark cutaneous surface. The prevailing colour is white, with long funereal-looking plumes of a purplish black colour, proceeding from beneath the tertiary wing-feathers, and hanging down not ungracefully on either side. The legs and feet are deep lead-colour. Among the ancient Egyptians, a people prone to award divine honours to the brute creation, the ibis was regarded as an object of superstitious worship, and its sculptured outline frequently occurs among the hieroglyphical images which adorn the walls of their temples. The conservation of its mystical body occupied the assiduous care of their holiest priests while living, and exercised the gloomy art of their most skilful embalmers when dead. To slay or insult it would have been deemed a crime of the darkest hue, and sufficient to call down upon the offender the immediate vengeance of heaven. The incarnation of their gods was effected through the medium of this sacred bird, and the tutelary deity of Egypt was supposed to be thus imaged to the eyes of adoring mortals when he descended from the highest heavens. The embalmed bodies of this species are still found in the catacombs, and other places of ancient sepulture; and the antiquary and the naturalist marvel alike at the wonderful art which, for some thousand years, has handed down unimpaired to a far-removed posterity the form and features of so frail a creature. The perfection of an unknown process has almost defied the ravages of time, and through its intervention the self-same individuals exist in a tangible form, which wandered along the banks of the mysterious Nile in the earliest ages of the world, or "in dim seclusion veiled," inhabited the sanctuary of temples, which though themselves of most magnificent proportions, are now scarcely discernible amid the desert dust of an unpeopled wilderness.

The natural and mythological histories of this remarkable bird are so closely combined by ancient authors, that it is scarcely possible to gather from their statements any rational meaning. Those, indeed, whose province it is to illustrate the history of mankind, by explaining the rise and progress of superstition, and the frequent connection between certain forms of a delusive worship, and the physical conditions of clime and country, may find in the distorted history of Egyptian animals an ample field for the exercise of such ingenious speculations; but the Zoologist has to do rather with things as they are, than as they were supposed to be,—and his province is to explain (or attempt so to do) the works of the God of nature as they exist in their most beautiful and harmonious simplicity, undeformed by the multitudinous fables of a remote antiquity. We need not, then, to inquire whether the basilisk be born from an egg produced in the body of the ibis, by a concentration of all the poison of all the serpents which it may have swallowed in the course of a long and reptile-eating life;—nor whether the casual touch of its lightest plume still suffices not only to enchant and render motionless the largest crocodile, but even to deprive it at once of life;—nor whether the ibis itself, according to an expression of the priest of Hermopolis, sometimes attains to so great an age that "it cannot die," unless when, removed from the sustaining soil of its beloved Egypt, it sinks beneath the *nostalgia* of a foreign land! For we know that the basilisk does not exist; that young ibises have been seen flapping themselves across the outstretched bodies of sleeping crocodiles, which afterwards sought the waters of the Nile with their accustomed alacrity; and that the age of the sacred bird, though from the skill of the embalmers it may be said to be "in death immortal," does not exceed that of the rest of its congeners.

The sacred ibis is usually observed either in pairs, or in small groups of eight or ten together. They build their nests on palms and other elevated trees, and lay two or three whitish eggs. They do not breed in Egypt, but arrive in that country when the waters of the Nile begin to swell. This apparent connection (as of cause and effect) between the presence of these birds and the fertilizing flow of the mighty and mysterious river, probably gave rise to their worship as divine agents in immediate connection with those grander processes of nature by which the surface of the earth was regulated, and sustained in a fit condition for the health and prosperity of the human race. A slight knowledge of natural history would indeed have sufficed to show, that such divine honours had not been awarded as a consequence of their destruction of serpents and other venomous reptiles; for the modern Egyptians confirm the views of Colonel Grobert, that the ibis does not prey on serpents at all, but feeds very much after the manner of the curlew, on insects, worms, small fishes, and molluscous animals.[1]

A smaller sized though much more splendidly attired species, is the scarlet ibis (*I. ruber*) of America. This brilliant bird is confined to the new world, where it is chiefly tropical, abounding in the West Indies and the Bahama Islands, and stretching southwards of the equator at least as far as Brazil. In the course of the summer (generally in July and August) it migrates into Florida, Alabama, Georgia, and South Carolina, retiring into Mexico and the Carribbean Islands on the approach of the winter season. It is gregarious, feeding along the sea-coast, the shores of estuaries, and the banks of rivers, on small fry, shell-fish, insects, and worms. Although they often perch on trees (where the contrast of their fiery plumage with the surrounding foliage is said to produce a most resplendent effect), they build their nests upon the ground. The young for several seasons exhibit obscure shades of brown, they afterwards become spotted with red, and then assume the splendid attire of the parents, which is a uniform and dazzling scarlet, with the exception of the extremities of the first four primaries, which are of a rich bluish black. Pennant says that the scarlet ibis has been domesticated in Guiana; and Dr Latham possessed one which was brought alive to England, and lived for some time with his poultry. It is clear from the statements of American writers, that it is, at least in temperate countries, a bird of passage, although Cuvier observes, "que cette espèce ne voyage point." When taken young it is easily tamed, and submits to domestication without repining. Delaet says it has even propagated in captivity; and M. Delaborde has given the history of an individual which he kept for above two years, feeding it on bread, raw or cooked meat, and fish. It was fond of hunting in the ground for worms, and was in use to follow the gardener in expectation of that favourite food. It roosted at night upon the highest perch in the poultry-house, and flew out at an early hour of the morning, sometimes to a great distance from home. Our climate is probably too cold and variable for a bird which

[1] Wilson's *Illustrations of Zoology*, vol. i. pl. xix.

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on the approach of winter always migrates southwards, otherwise it would assuredly form a splendid (it is even said a savoury) addition to our stock of domestic fowls.[1]

In the genus NUMENIUS, Cuv., the bill is arched, as in the preceding, but still more slender, and rounded throughout its entire length, instead of being square at the base. The extremity of the upper mandible extends beyond the under one, and projects a little over it at the base. There is an obvious palmation at the root of the toes.

To this genus belong the curlews,—well-known birds, of shy and wary habits, which, according to the season, haunt either the hilly pastures or the sandy shores. The North American species (*N. longirostris*, Wilson) is remarkable for the extraordinary length of its bill. (See Plate CCCC. fig. 3.) The common curlew of Britain (*N. arquata*) seems to inhabit exclusively, during the breeding season, our upland moors and pastures, and descends to the sea-coasts in winter. The smaller British species, called whimbrel (*N. phæopus*), seems scarcely known in England during summer, but is then frequent in the north of Scotland, where it breeds. It is distinct from any of the American curlews,—with one of which, however, it has sometimes been confounded. A nearly allied species, first described by M. Vieillot under the title of *Numenius tenuirostris*, as a native of Egypt, has been ascertained by C. L. Bonaparte to exist in great numbers along the banks of the Tiber, where it occurs during winter. It has also been discovered by Signor Savi in the neighbourhood of Pisa, by Dr Pajola in the Venetian territory, and by Professor Bonelli in Piedmont. We doubt not it occurs occasionally in most parts of Europe (especially the eastern countries), although it escapes detection in consequence of its strong resemblance to the common whimbrel. Its distinctive phrase is—Numenius pileo cicerino e nigro maculato: pennis longioribus ilium candidis, immaculatis.[2] The small esquimaux curlew (*N. borealis*, Lath. and Richardson) passes over a vast extent of territory in its migrations,—breeding in the barren lands within the arctic circle, and spending the winter in Brazil.

In the genus SCOLOPAX, Cuv., containing the snipes and woodcocks, the bill is very long, but straight, and pervaded almost throughout its entire length by a nasal furrow. The upper mandible is slightly inflated at the tip, which is rather soft, and extremely delicate in its perceptions. The feet are not palmated. The head is compressed, the eyes large, and situate far back upon the head,—"ce qui," says Cuvier, "leur donne un air singulièrement stupide, qu'ils ne démentent point par leurs mœurs." Now, though the birds in question may want those accommodating instincts which elevate the character of many other species almost into a semblance of reason, we are not aware that they are in any way of defective intellect, that is, that their proceedings are at all discordant with self-preservation, the enjoyment of their natural propensions, or the continuance of their kind; and as to the position of the eye, whatever may be its physiognomical effect, is it not admirably adapted to their general modes of life, and their particular habit of plunging their bills into the mud of marshes, enabling them so to do, and yet to keep a sharp look-out around them? Depend upon it, their eyes are in the right place, and their large size cannot be otherwise than advantageous to birds which feed by night.

We have five British species of *Scolopax*, of which the woodcock (*S. rusticola*) is the chief, a bird much admired by epicures, who eat him, entrails and all,—a dirty practice, we opine: but, *de gustibus non disputandum est.* During the day this species usually frequents the closest brakes, where the ground, from depth of shade, is nearly free from herbage. They abound most in thickets by the sides of open glades, or where roads intersect; for by these they pass to and from their feeding ground at evening and the dawn of morn. "Unless disturbed," says Mr Selby, "they remain quietly at roost upon the ground during the whole day; but as soon as the sun is wholly below the horizon, they are in full activity, and taking flight nearly at the same instant, leave the woods and cover for the adjoining meadows or open land, over which they disperse themselves, and are fully engaged in search of food during the whole night. Advantage has long been taken of this regular mode of going to and returning from the feeding grounds by the fowler, in those districts where woodcocks are abundant, by suspending nets across the glades, or by the sides of hedges, where they are observed to pass continually; and though the adoption of the fowling-piece has in general superseded the modes of capture formerly practised, great numbers are still taken in this manner in Devonshire and Cornwall. Another method of entrapping woodcocks (as well as snipes) is by the springe, which is set in places where those perforations made by the bill of the woodcock in search of food, and technically called *borings*, are observed to be most frequent. It is formed of an elastic stick, of which one end is thrust into the ground, the other having affixed to it a noose made of horse-hair; the stick being then bent down, this noose is passed through a hole in a peg fastened to the ground, and is kept properly expanded by means of a fine trigger, so set as to be displaced by the slight pressure of the bird's foot. To conduct them to this trap, a low fence of twigs, or of stones placed so closely together as to leave no passage through the interstices, is extended to some distance on each side of the springe, and generally in an oblique direction; over which obstacle, however trifling, it seems the birds never attempt to hop or fly, but keep moving along it, till they approach the part occupied by the noose of the springe: upon attempting to pass through this apparently open space, they displace the trigger, and are almost invariably caught by the noose, and retained by the spring of the stick against the opposing peg. Day being the woodcock's time for repose, it sits very close, and is not easily *flushed;* the sportsman then requiring the aid of the busy spaniel, or the bush in which it is ensconced to be actually beaten by an attendant, before it will take wing. It rises, however, with much quickness, and threads its way through the branches with great rapidity, until the underwood and trees are fairly cleared, when its flight becomes measured, and offers an easy aim to the sportsman. When roused, it seldom flies to any great distance, but alights in the first thicket that attracts its attention, closing its wings, and dropping suddenly down, and in such cases it is not unusual for it to run a little way before it squats. Just before rising, upon being disturbed, or when running, it jerks its tail upwards, partly expanding it, and fully showing the white that distinguishes the under surface of the tips of the tail-feathers. In feeding, the woodcock inserts its bill deep into the earth in search of worms, which are its favourite and principal food. This instrument is most admirably calculated for the offices it has to perform when thus immersed in the soil; for, in addition to its great length, it possesses a nervous apparatus distributed over a great portion of its surface, and especially on such parts as are likely to come first into contact with its prey, giving it

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[1] *Gardens and Menagerie of the Zoological Society.* We do not know how it has happened that the wood-cut of the scarlet ibis in the work just referred to is copied into Mr Nuttall's excellent *Manual of American Ornithology*, under the name of wood ibis, *Tantalus loculator*,—a bird which belongs to a different genus.

[2] *Ornitologia Toscana*, tom. ii. p. 324.

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the sense of touch in the highest perfection; and to enable it to secure the object thus detected by the discriminating sensibility of the bill, it is further provided with peculiar muscles (common, I believe, to all the members of the genus), which by compression of the upper or basal part of the bill, are brought into action so as to expand the tips of both mandibles sufficiently wide to lay hold of and draw forth the hidden treasure. The digestion of this bird is rapid, and the quantity of worms it can devour in the course of a night is astonishing. I have known one that consumed at a meal (that is, within the night) more large earth-worms than half filled a garden-pot of considerable size. It may, however, by management, be brought to eat other food; as Montagu mentions one that was induced to feed on bread and milk, by worms cleanly washed being put into a mess of that kind; and by this practice being persisted in, the bird soon acquired a relish for this new sort of aliment, and, with the addition of a few worms, throve well upon it."[1] We have already mentioned that the woodcock is now of frequent and constant occurrence as a breeding bird in several of the northern parts of Scotland.

Our other species of this genus are the common snipe, *S. gallinago*, Linn., which also occurs in the temperate parts of Asia; and the jack-snipe, *S. gallinula*, a winter visitant, which breeds, though sparingly, in the north of Scotland. Besides these, we have as occasional visitants,—the great or solitary snipe, *S. major*, Gmel., which haunts the vast marshes of the north of Europe,—and a species of which only one or two examples have been as yet discovered (it was first shot in Queen's county, Ireland, we believe in 1822), named *S. Sabini*, by Mr Vigors.[2] Although some of these birds have an extended geographical distribution, the great similarity of several species, both in size and plumage, has caused misapprehension. There is now no doubt that the species of Europe and America are quite distinct. The lesser woodcock, *S. minor*, is a beautiful bird, well known in the United States. The brown snipe of Pennant (*S. grisea*, Gmel.) forms the genus Macroramphus, Leach. Its toes are webbed at the base.

The genus Rhynchæa, Cuv., has the bill very similar to that of the snipes and woodcocks, but it is slightly arched towards the tip, and wants the furrow on that part. The toes have no palmation. The species are more richly coloured than their congeners, and, in consequence of their occasional variation, have been as yet but indifferently distinguished. The Cape species so called (*R. capensis*,—*Scol. capensis*, Gm., Plate CCCC. fig. 4), occurs in Java and the East Indies; while *R. variegata*, by some regarded as its young, has been received both from China and the south of Africa. A very distinct species, however (*B. hilarea*), described by M. Valenciennes, has been discovered in South America.[3]

In the genus Limosa of Bechstein, the bill is still longer than among the woodcocks, straight, or even slightly turned upwards, and pervaded by lengthened grooves, although the terminal single groove is wanting. The tip is blunt and depressed. There is a palmation at the base of the outer toes. The general form of the species is more slender, and the legs longer, than in the immediately preceding groups. They haunt more habitually saline marshes and the sea shore.

We here place the birds called *godwits*, of which we have two British species,—the black-tailed godwit, *L. melanura*, Leisler and Temm. (*Scol. ægocephala*, Linn.), and the red godwit, *L. rufa*, Briss. (*Scol. Lapponica*, Linn.). Of both of these birds the synonyms, till lately, were greatly confused, owing to the double moult to which they are subject, and which, producing a remarkable change in the nuptial plumage from that of autumn and winter, led to a corresponding multiplication of names,—each kind being described as two species, according to the season in which it was observed. Although the bill in the godwits possesses much of the general form of that of the woodcocks, it wants the extraordinary plexus of nerves, and therefore does not become rugose by exsiccation after death, but continues smooth and polished. It is also more solid, less flexible, and thicker towards the base. These birds inhabit marshes, and the banks and mouths of rivers, where the mud is soft and deep, and there they probe with their long extended bills in search of worms and insects. When thus engaged, they are frequently seen with their heads entirely under water; and we accordingly find them provided with that peculiar gland above the eye, of which the function appears to be to lubricate and defend that delicate and important organ from the irritating effect of saline waters.[4] The females considerably exceed the males in size. Several fine godwits, distinct from those of Europe, occur in North America; and a semi-palmated species, with a strongly recurved bill (*Scol. terek*, Lath.), is found both in India and Van Diemen's Land, and seems in some of its characters to lead towards the avocets.

In the genus Tringa of Temm., Selby, &c. (*Calidris* and *Pelidna*, Cuv.), the bill equals or is longer than the head, is straight or slightly arched, compressed at the base, the tip blunt, smooth, and dilated, semi-flexible, and furrowed throughout its length. The legs are of medium length, very slim, the feet four-toed, divided to the base, slightly margined, with the hind toe scarcely reaching to the ground.

The elegant and interesting species which compose this rather numerous genus are commonly known by the name of sea-larks or sandpipers, a term likewise bestowed upon the *Totani*. Many of them breed by the margins of lakes and rivers in the interior, although the majority congregate in autumn in numerous flocks along the sea coast. They moult twice a year, and their spring and summer plumage is generally very different from that of autumn and winter. This has occasioned great confusion in the history of several species. The sexes present no great disparity in point of plumage, but the females are of larger size. We coincide in Mr Selby's opinion, that the new genera *Calidris* and *Pelidna*, which Baron Cuvier has proposed in place of *Tringa*, are not so distinct or well defined as to warrant their adoption, being in fact only such slight modifications of form as might naturally be expected in birds placed at the extremes of the group to which they belong, and of which the intimate connection is shown by the intervention of species of intermediate form, leading gradually, almost imperceptibly, from one to the other. Besides, if these two generic groups are adopted, it would appear that *Tringa* would cease to exist as a recognised title, which is surely not in accordance with established rule. The species of our present genus are very widely distributed, and several are identical in Europe and America.

The dunlin or purre, *T. variabilis*, Temm. (*T. alpina* and *cinclus*, Linn.), is a strictly indigenous bird in Scotland, where it breeds both near the margins of our inland waters and along the sea-shore,—residing with us throughout the year. In America it penetrates during the summer season to the utmost habitable verge of the arctic circle, breeding on the desolate shores of Melville Peninsula. It likewise inhabits Greenland, Iceland, Scandinavia, and probably most of the coasts of Europe. We know that at least during winter it frequents the Italian shores. In the southern hemisphere it sometimes wanders as far as the Cape of

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[1] *British Ornithology*, vol. ii. p. 110.
[2] *Linn. Trans.* vol. xiv. p. 556.
[3] Ferrussac's *Bulletin des Sciences*, 2d cah.
[4] Selby's *British Ornithology*, vol. ii. p. 94.

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Good Hope, and has been met with both in the West Indies and South America. When flying in great autumnal flocks, its aërial movements are extremely beautiful, each individual of the vast assemblage yielding so instantaneously to the same impulsion as to exhibit alternately the upper and the under surface of the body, so that we have for a time a living moving cloud of dusky brown, and then a brilliant flash of snowy whiteness.

The larger species, called the knot (*T. canutus*, Linn.), has also a vast range in a northerly direction. It passes the summer within the arctic circle, breeding in Melville Peninsula, and in Hudson's Bay, as far south as the fifty-fifth parallel. It lays four eggs of a dun colour, spotted with red, upon a tuft of withered grass. The knot winters in Britain, but many proceed much farther south, as we know they occur towards the end of autumn in the Venetian territory. The great mass of the North American knots pass over the United States, and spend the winter within the tropics. The other British species are *T. rufescens*, *Temminckii*, *minuta*, *maritima*, and *subarquata*.

The genus ARENARIA, Bechstein, closely resembles the sandpipers of the genus Tringa, but is distinguished by the entire absence of the hind toe. The only known species is the sanderling (*A. calidris*), one of our winter birds of passage, which breeds in the remotest northern regions, forming a rude grassy nest among the desolate marshes, and laying four dusky coloured eggs, spotted with black.

The genus FALCINELLUS, Cuv. (composed of *Scol. pygmæa*, Linn.), has the bill considerably arched, and the hind toe wanting. The only known species is an African bird, which occasionally makes its appearance in Europe. M. Temminck seems to think it should be regarded rather as a synonym than a distinct actual species.

The genus MACHETES, Cuv., bears a great resemblance to *Tringa*, except that there is an obvious palmation at the base of the toes. It contains only one species, commonly called the ruff (*T. pugnax*, Linn.), well known in the Lincolnshire fenns and the London markets (see Plate CCCC. fig. 5). It is a summer bird of passage, arriving in the fenny districts of England in the month of April, and departing towards the end of September. The ruff, as its specific name implies, is a remarkably pugnacious species, a disposition which probably arises from its polygamous habits, in which it differs from its congeners. Some people say there are more males than females. Be this as it may, as soon as these birds arrive, each male fixes upon a small hillock or dry grassy spot among the marshes, where he keeps turning about till he has almost trodden it bare; but the moment a female makes her appearance, a general combat commences, the male birds lowering their heads, expanding their neck-feathers, and flying at each other with the action of fighting cocks. These battles are obstinate and long continued, and whoever proves the victor for the time obtains the female. They disperse at night for the sake of feeding, but every morning soon after daybreak each male returns to his hillock, where the same scenes of rivalry and love take place, and continue till their passionate fervour is abated, towards the end of June. The plumage of the ruff presents an almost infinite variety, scarcely two individuals being ever found precisely the same. The lengthened feathers of the head and neck are produced in spring, and shed towards the close of summer; and during autumn and winter the plumage becomes so different from that of the breeding season, that the birds would not be recognised as the same by any one previously ignorant of such mutation. Their flesh is highly esteemed as a delicate and nutritious food. Though these birds extend northwards as far as Iceland, and the colder parts of Russia, they never visit Scotland, the marsh of Prestwick Car, near Newcastle, appearing to be their British boundary. They occur, though rarely, in North America. Though their natural food is worms and water insects, they fatten soon in confinement on boiled wheat, or bread and milk mixed with bruised hempseed.

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The genus HETEROPODA of Nuttall has the bill straight, rather enlarged and punctate at the extremity, the tarsus of moderate length, the three anterior toes connected at the base by a membrane. Example, *Tringa semipalmata*, Wilson. In the genus HEMIPALMA, Bonaparte, the bill is much larger than the head, partly arched, dilated, and studded at the tip with minute tubercles. The tarsus is very long, and the toes are usually connected by a membrane as far as the first articulation. The species are called stilt sandpipers, of which *H. himantopus* was discovered by C. L. Bonaparte and Mr Cooper. Both these genera are American.

In the singular genus EURINORHYNCHUS, Wilson, the bill is short, thin, depressed, spoon-shaped, the tarsi short, slender, reticulated. The only known species is a very rare and remarkable bird, *E. griseus*, native, it is supposed, both to Europe and America.[1] It was formerly classed with the spoon-bills (*Platalea pygmea*, Linn.), though scarcely larger than a sparrow. There is a specimen in the French Museum, which was accidentally killed near Paris. The plumage is gray above, white beneath.

In the genus PHALAROPUS of Brisson, the bill, though more flattened, resembles that of *Tringa*, but the toes are margined by a broadish membrane. In their habits the species are more aquatic than most of their congeners; for though they cannot dive, they float buoyantly on the surface, or even make their way by swimming with almost the ease of the regularly web-footed birds. The gray phalarope or scallop-toed sandpiper (*Phal. lobatus*, Flem.) is found occasionally in Britain during winter. It breeds habitually within the arctic circle, in Hudson's Bay, among the North Georgian Islands, and along the sterile shores of Melville Peninsula. According to Mr Bullock, it is not uncommon in the marshes of Sunda and Westra, the most northerly of the Orkney Isles. When seen swimming in pools, it is continually dipping its bill into the water, as if feeding on some minute aquatic creature. The plumage varies greatly with the season, and a variety of names have been bestowed in consequence of these mutations. The red phalarope (*Tringa fulicaria*, Linn.) represents the summer plumage. It was seen by our northern navigators on the 10th of June, in latitude 68°, swimming at its ease though several miles from land, but surrounded by mountains of ice.

In the genus STREPSILAS, Illiger, the legs are rather low, the bill short, and the toes without palmation as in *Tringa*, but the bill is conical and pointed, with the nasal fissure extending only one half its length. The hind toe nearly touches the ground. The only known species, *St. interpres* (of which *St. morinellus* is the young) is a winter bird of passage on the mainland of Britain, though it breeds and remains throughout the year among the Shetland Isles. The turnstone, as it is vernacularly called, is one of the most generally distributed of birds, being found at some season or other in almost every region of the globe. The English name is derived from its habit of turning over little stones along the shore in search of food, which it is enabled to do by its bill being proportionally stronger and stiffer than that of its congeners.

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[1] *Acad. Suec.* 1816, pl. vi.

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In the genus TOTANUS, Cuv., the bill is slender, round, pointed, firm, the upper mandible slightly arched, with the nasal groove not extending above half its length. The form is light and active, the legs rather long, the toes webbed at the base, more especially between the outer and middle toe. In birds of this genus, as Mr Selby has observed, the comparatively hard and sharp-pointed bill indicates a corresponding change in habits and economy; so that instead of seeking their food by probing in the sand or softer mud, they search for it along the pebbly banks of lakes and rivers, or the ocean's gravelly shore. Some reside habitually in inland districts, while others prefer the sea-coast, or migrate thither during the autumnal season. The British species are the dusky sandpiper, *T. fuscus*, Leisler; the redshank, *T. calidris*, Bechst.; the green sandpiper, *T. ochropus*, Temm.; the wood sandpiper, *T. glareola*, Temm.; the common sandpiper, *T. hypoleucos*, Temm.; and the greenshank, *T. glottis*, Bechst. Besides which, the spotted sandpiper, *T. macularia* (a very common species in North America), &c. are of occasional occurrence. Regarding the last-named species, Mr Bartram informed Alexander Wilson, that he saw one of these birds defend her young for a considerable time from the repeated attacks of a ground squirrel. The scene of action was on the river shore. The parent had thrown herself, with her two young behind her, between them and the land; and at every attempt of the squirrel to seize them by a circuitous sweep, she raised both her wings in an almost perpendicular position, assuming the most alarming aspect possible, and rushing forwards on the squirrel, which for a time drew back intimidated; but soon returning, was met as before by the affectionate but infuriated bird, her wings and whole plumage bristling up to twice their natural size. This interesting, but, for one of the parties, fearful play, continued for about ten minutes, when the strength of the bird began to flag, and the attacks of the quadruped became more audacious, on which Mr Bartram interfered, "like one of those celestial agents," says Wilson, "who in Homer's time so often decided the palm of victory"! The green-shank (*T. glottis*), though usually regarded as merely a passenger in spring and autumn, is now known to breed in Scotland. It inhabits the northern parts of both continents, but is rarer in the new world than the old. Mr Audubon traced it as far south as the Tortugas, near the extremity of East Florida, and Latham received it from Jamaica. It also occurs in Bengal. Our common red-shank (*T. calidris*) is found occasionally in North America. A large species well known in the western world by the name of *willet*, and characterized by all the anterior toes being conspicuously webbed at the base, forms M. Bonaparte's genus CATOPTROPHORUS. This bird not only wades, but swims. It is the semi-palmated snipe (*Scol. semi-palmatas*) of the older systems.

The genus LOBIPES of Cuvier combines the bill of the preceding genus (*Totanus*) with the lobated toes of *Phalaropus*. We may mention as an example the red-necked phalarope,—*Tringa hyperborea*, Linn. (*Lob. hyperborea*, Cuv.), a species not uncommon among our northern islands, where it swims with great ease,—resembling when in the water a beautiful miniature representation of a duck. It likewise breeds all along the forlorn shores of arctic America, resorting to Hudson's Bay in autumn. Another species (*L. Wilsonii*) seems confined to the new world, where it breeds on the banks of the Saskatchewan, and occurs at least as far south as Mexico. It does not advance to so high a northern latitude as the hyperborean species, being as yet unknown beyond the fifty-fifth parallel. It forms an artless nest within the shelter of some grassy tuft, laying two or three pear-shaped eggs, of a tint between yellowish gray and cream colour, interspersed with small roundish spots, and a few larger blotches of umber-brown towards the obtuser end. It can only be regarded as a straggler in the United States. This bird forms the subgenus HOLOPODIUS of Bonaparte, the basal web between the inner and middle toe being less than in the preceding species. The synonyms of both are still somewhat confused.

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The genus HIMANTOPUS, Brisson, has the bill round, slender, pointed, the nasal furrow extending only half its length. But the principal and most peculiar character consists in the enormous length of the leg and tarsus, from which the species have derived the title of stilts, or long-legged plovers. The toes are united by a basal web, larger on the outer than the inner portion of the foot. These birds have a greater predilection for the borders of the sea, and for brackish lakes, than for the banks of rivers or pure fresh-water lakes. Their movements are rapid on the wing, but their gait is somewhat staggering, from the disproportionate length of their legs. The kind which occurs in Europe (*Him. melanopterus*, Meyer), called the black-winged stilt, has been known to breed in France, and accidentally visits England, but its chief resorts are the great salt marshes of Hungary and Russia. It is often seen in Italy in little flocks in spring, travelling northwards. It likewise occurs in Asia, Africa, and America; but the species of the new world, described by Wilson, is the *Him. nigricollis* of Vieillot. We shall here quote his account of its manners and mode of nidification, as the history of the European stilt, in these particulars, is scarcely known. "This species arrives on the sea-coast of New Jersey about the 25th of April, in small detached flocks of twenty or thirty together. These sometimes again subdivide into lesser parties; but it rarely happens that a pair is found solitary, as during the breeding season they usually associate in small companies. On their first arrival, and indeed during the whole of their residence, they inhabit those particular parts of the salt marshes pretty high up towards the land, that are broken into numerous shallow pools, but are not usually overflowed by the tides during the summer. These pools or ponds are generally so shallow that with their long legs the avocets can easily wade them in every direction; and as they abound in minute shell-fish, and multitudes of aquatic insects and their larvæ, besides the eggs and spawn of others deposited in the soft mud below, these birds find here an abundant supply of food, and are almost continually seen wading about in such places, often up to the breast in water.

"In the vicinity of these bald places, as they are called, fifty yards off, among the thick tufts of grass, one of these small associations, consisting perhaps of six or eight pair, takes up its residence during the breeding season. About the first week in May they begin to construct their nests, which are at first slightly formed of a small quantity of old grass, scarcely sufficient to keep the eggs from the wet marsh. As they lay and sit, however, either dreading the rise of the tides, or from some other purpose, the nest is increased in height with dry twigs of a shrub very common in the marshes, roots of the salt grass, sea-weed, and various other substances, the whole weighing between two and three pounds. This habit of adding materials to the nest after the female begins sitting, is common to almost all other birds that breed in the marshes. The eggs are four in number, of a dark yellowish clay colour, thickly marked with large blotches of black. These nests are often placed within fifteen or twenty yards of each other; but the greatest harmony seems to prevail among the proprietors. While the females are sitting, the males are either wading through the ponds or roaming over the adjoining marshes; but should a person make his appearance, the whole collect together in the air, flying with their long legs extended behind them, keeping up a continual yelping note of *click, click, click*. Their flight is

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steady, and not in short, sudden jerks, like that of the plover. As they frequently alight on the bare marsh, they drop their wings, stand with their legs half bent, and trembling, as if unable to sustain the burden of their bodies. In this ridiculous posture they will sometimes stand for several minutes, uttering a curring sound, while, from the corresponding quiverings of their wings and long legs, they seem to balance themselves with great difficulty.

"This singular manœuvre is, no doubt, intended to induce a belief that they may be easily caught, and so turn the attention of the person from the pursuit of their nests and young to themselves. The red-necked avocet practises the very same deception, in the same ludicrous manner, and both alight indiscriminately on the ground or in the water. Both will occasionally swim for a few feet, when they chance in wading to lose their depth, as I have had several times an opportunity of observing."[1]

The singular birds called avocets form the genus RECURVIROSTRA, Linn. Their feet are almost as fully palmated as those of certain Natatores, yet they are generally classed among the Grallatores, by reason of their lengthened tarsi, and legs bare above the knee. The bill also has the same lengthened, slender, pointed form, and smooth elastic structure, which characterize our present order, with which the birds in question agree in their general mode of life. The character which distinguishes them from all other birds is the extraordinary upward curvature of the bill (see Plate CCCC. fig. 6). The avocets live either in pairs or small companies in the midst of marshes, where they wade about with great ease, and to a considerable depth, in consequence of their bodies being raised so high above the surface. Though web-footed, they do not swim except by compulsion; yet one which Wilson wounded attempted repeatedly to dive, but the water was too shallow for his purpose. They run rapidly, and their flight is powerful and long sustained. Their nests are described as small cavities in the earth, lined with a few weeds, or merely the bosom of the bare sand; sometimes, however, they are raised several inches above the surface, as if to avoid the effects of moisture or inundation. The European species (*R. avocetta*, Linn.) is not uncommon along the eastern coasts of England south of the Humber. It breeds in the fenny parts of Lincolnshire and Norfolk, as well as in Romney Marsh in Kent. They assemble during winter in small flocks, frequenting the oozy shores about the mouths of rivers, where they scoop out small worms and mollusca. Buffon indulges in one of his characteristic vagaries while discussing the singular bill of this bird, which he supposes to be "one of those errors or essays of nature, which, *if* carried a little further, would destroy itself; for *if* the curvature of the bill were a degree increased, the bird could not procure any sort of food, and the organ destined for the support of life would infallibly occasion its destruction." This essay of nature is, however, as it happens, a most successful one; for by means of its lengthened legs and upturned bill, the avocet feeds with facility in muddy marshes, where if otherwise organized it would probably starve. *If* a devoted servant of God, while tonsorially engaged on some beautiful Sabbath morning, were to move the edge of his glittering blade an inch nearer his carotid artery, he would die, leaving behind him, in all probability, a disconsolate widow, and a large family of small children; but as he takes especial care to move his useful weapon in another direction, the artery remains intact, and the crime of suicide unaccomplished. We doubt not that the curvature of the bill in question could not have been better projected even by Buffon himself, although he was addicted in his youth to mathematics. The American avocet (*R. Americana*, Linn., Plate CCCC. fig. 6) has the head and neck pale rufous, and the bill takes a downward curve towards the extremity. Though abundant on the banks of the Saskatchewan, as far as the fifty-third parallel, it does not seem to proceed into the more northern regions. Besides these species, there are the *R. alba* of Latham (*R. orientalis*, Cuv.), from India; and the *R. rubricollis*, Temm., a native of New Holland. Our indigenous species also occurs both in Asia and Africa.

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FAMILY V.—MACRODACTYLES.

The prevailing character of this group consists in the extremely long narrow form of the toes, which are without any connecting web. Nevertheless the species run with great ease in moist places, and some of them swim very swiftly. The bill, more or less compressed laterally, varies in length in different genera, but is never so delicately slender as among the preceding family. The body in these birds is much compressed, a form determined in a great measure by the narrow nature of the sternum. The wings are of medium length, or short; and the power of flight, though necessarily efficient in such as are birds of passage, is on the whole restricted, or but sparingly exercised. The posterior toe is of considerable length.

The first genus, called PARRA by Linnæus, contains the jacanas, by some named spur-winged water-hens. The bill is rather longer than the head, nearly straight, laterally compressed, and somewhat enlarged both above and below towards the extremity. There is usually a small fleshy shield upon the base of the forehead. The toes are of great length, very narrow, unwebbed, and the claws, especially the hinder one, very long and sharp (see Plate CCCC. fig. 7). The anterior angle of the wing is armed with a spur. The jacanas occur in the warmer countries of the world—in Bengal, Java, the Celebes, China, South America, and parts of Africa. They inhabit marshy places, and run with great facility over the surface of aquatic plants, their long, extended toes spreading over so much space as to prevent their sinking in the water. They feed on insects, build their nests among the moist herbage, and lay four or five greenish eggs spotted with brown. Their flight, though low, is rapid. They are shy and silent birds, except at night, when their voices are often heard among the marshes. The Chinese jacana of Latham (*Parra sinensis*, Gmelin) is found both along the marine shores and the moist plains of the interior. This species, as Mr Gould observes, is distinguished not more by grace and beauty of form, than by its admirable adaptation to the particular localities to which nature has allotted it. Formed for traversing the wide morass, or lotus-covered surface of water, it supports itself upon the floating weeds and leaves by its extraordinary extent of toes and unusual lightness of body. Like our common water-hen, of whose habits and manners it partakes largely, it is no doubt capable of swimming, although the long and pendent tail-feathers seem an inconvenient appendage for such a purpose. Its powers of flight appear deficient, the quill-feathers being terminated by a slender process proceeding from the tip of each shaft. This singular bird has been long known as a native of the low lands of India and other eastern countries, but was not till lately ascertained to occur in the Himalaya, where it inhabits lakes and swamps among the hills.[2] Another eastern species (*P. gallinacea*, Temm. *Pl. Col.* 464) is provided with a crest, but wants the spurs upon the wings.

In the genus PALAMEDEA, Linn., the bill is rather short, conical, compressed, convex, and curved at the extremity. There is a bare space around the eyes, the wings are am-

[1] *American Ornithology*, vol. iii. p. 76.

[2] *Century of Birds from the Himalaya Mountains.*

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ple, furnished with strong spurs. The tarsi are short and thick, the toes and claws long. Some systematic writers include in this genus only a single species, *P. cornuta*, Linn., called kamichi or the horned screamer, a South American bird, larger than a goose, with a slender moveable horny projection on the forehead. Though this bird affects inundated places, its toes are without palmation. In its general aspect, and several of its special habits, it exhibits an approach to the gallinaceous order; and although its stomach is but slightly muscular, it lives much on grain and herbage.[1] It is also easily reduced to the domestic state; and although it lays only two eggs, the young speedily follow the parents.

It is by no means easy to conjecture the natural uses of these formidable weapons on the wings of this and several other species. One would suppose them intended to wage war among their kind,—yet the birds so endowed are for the most part peaceable, and averse to broil and battle,—even in most instances of a timid and fearful nature; and in the case of several of the plover tribe, there is no appreciable difference in the habits of the armed and unarmed kinds. All who have studied the manners of the kamichis agree that they are the gentle inhabitants of moist savannahs, or the shores of those extensive rivers which intersect the southern portion of America, and that there is nothing pugnacious in their temper. Yet they are "doubly armed," the margin of each wing bearing a pair of very large spurs, thick at the base, but tapering sharply to a point, and, no doubt, when driven forcibly forward by the muscular action of a powerful wing, capable of inflicting such a blow as would at once deprive most small animals of life.

Another bird, by some referred to our present genus, is *Pal. chavaria*, Temm. (*Pl. Col.* 219), the *Parra chavaria* of Linn., known in some English works as the faithful jacana. Instead of a horn, its head is ornamented by a feathered crest, and there is an obvious palmation between the outer and middle toes. For these and other reasons it forms the genus Chauna of Illiger. Its head and upper neck are clothed with down, the latter being surrounded by a black collar. The rest of the plumage is lead colour and blackish, with a white spot upon the front of the wings, and another on the base of the primaries. Linnæus, on the authority of Jacquin, gives the following history of this bird:—"It inhabits the rivers, lakes, and marshes, near the river Sinu, about thirty leagues from Carthagena, in South America. It feeds on vegetables; its gait is solemn and slow, but it flies easily and swiftly; it cannot run unless assisted by the wings at the same time. When any part of the skin is touched by the hand, a crackling is felt, though it is very downy beneath the feathers; and this down adheres so closely as to enable the bird at times to swim, notwithstanding the length of its legs and of its cleft feet; which latter enable it also to walk on the aquatic plants of the pools. It has two strong and pointed spurs on the bend of the wing, which are, however, hidden when the latter is closed, but when expanded they become formidable weapons, aided by the strong and lengthened wing; and by means of them it is able to drive off birds as big as the carrion vulture, and even that bird itself. The natives, who keep poultry in great numbers, have one of these tame, which goes along with the flock about the neighbourhood to feed during the day, when this faithful shepherd defends them against birds of prey: it never deserts the charge committed to its care, although able to fly, but returns home with them safe in the evening. It is so tame as to suffer itself to be handled by a grown person, but will not permit children to attempt the same. Its voice is clear and loud, but far from agreeable."[2]

Baron Cuvier here places the genus Megapodius, Quoy et Gaim., of which the bill is slender, straight, flattened, and enlarged at the base, restricted at the centre, and inflated towards the point. The tail is small and wedge-shaped. The general form is massive, the plumage usually brown, without lustre. The species inhabit New Guinea, the Marianne Islands, &c. and are described in the voyages of Freycinet and Duperrey. They are remarkable for the largeness of their eggs. Some authors place them with the genera *Crax* and *Penelope*, rather than in the grallatorial order.

The extensive genus Rallus, Linn., is in one or other of its forms known in almost every country of the world. With Bechstein, we would restrict the title to such as have the bill longer than the head, rather slender, compressed at the base, with the tip cylindrical, and slightly curved. As a British example may be mentioned our common water-rail (*R. aquaticus*), a shy and solitary bird, which resides throughout the year in Britain. It is extensively spread over Europe, but does not occur in America. The land-rails form the genus Crex, Bechstein, and have the bill shorter than the head, thick at the base, somewhat cultrate, and compressed. The wings are armed with a small concealed spine. Besides the well-known corn-crake (*C. pratensis*), a summer bird of passage, of which the deceptive note is heard so often during evening twilight, we have the spotted crake, *C. porzana*, Baillon's crake, *C. Baillonii* (Olivaceous gallinule of Mont.?), and the little crake, *C. pusilla*. The Carolina rail seems a *Crex* in the form of its bill, though its aquatic habits assimilate it to *Rallus*. It assembles during autumn in vast numbers on the reedy shores of the larger rivers in the middle and southern states of North America, and affords abundant occupation to sportsmen. Any active and expert marksman may kill ten or twelve dozen in a few hours. It winters to the south of the Union. The diet of the different species probably varies with time and place. The American bird just named is very fond of rice. Our own species feed both on grain and insects. Sir W. Jardine found a short-tailed field-mouse in the stomach of a land-rail. This bird is called king of the quails in some continental countries, in consequence of its arriving and departing with these birds.

The old genus Fulica, Linn., has, like the preceding, been also subdivided, in accordance with the form of the bill and lobation of the toes. For example, the genus Gallinula of Briss. and Lath. has the bill resembling that of *Crex*, but there is a flat fleshy shield upon the forehead. The toes are long, and bordered by an extremely narrow lateral margin. We here place our British gallinule, familiarly known by the name of water-hen, *G. chloropus*, Lath. This bird, though with us a permanent resident, is migratory in all the more northern parts of Europe. It occurs both in Asia and Africa, but not in America, as some erroneously suppose. It swims and dives well, though its feet might, *a priori*, be deemed but little fit for such aquatic service. The water-hen is of rather familiar habits, that is, a pair are sure to make their appearance as soon as any small artificial piece of water has been formed, even in the closest proximity to human dwellings. It builds by the water-side, and lays a great number of eggs, from eight to ten, which it is said to cover carefully during its occasional absence in search of food. The purple and Florida gallinules (*G. Martinica* and *galeata*) occur in North America; and a Javanese species (*G. ardosiaca*) is described by M. Vieillot.

In the genus Porphyrio of Brisson, the bill is higher in relation to its length than in the preceding. The toes are extremely long, with scarcely a perceptible bor-

[1] Bajon, *Mém. sur Cayenne*, t. ii. p. 284.

[2] Shaw's *General Zoology*, vol. xii. p. 272.

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der; and the frontal disk, sometimes rounded, sometimes square above, is of considerable size. The species are remarkable for richness of colouring. *P. hyacinthinus*, Temm. (*Fulica porphyrio*, Linn.), is an African species, not unfrequent in Sicily and Sardinia.

The genus FULICA, as now restricted, is chiefly distinguished from its congeners by a scallop-shaped or broadly-festooned membrane on each side of the toes. It contains the coots, of which *F. atra*, Linn., our common coot, affords a good example. This bird, as generally distributed in Britain throughout the summer season as the water-hen, leaves the northern portions of the island on the approach of winter. It dislikes being approached in open water, though a good diver, and quickly betakes itself to some protecting cover of reeds or other water-plants on every slight alarm. The cinereous coot of the western world (*F. Americana*, Gmel.) is a distinct species, though not so regarded by Alexander Wilson. It is widely spread over a vast extent of territory, from the steaming marshes of Jamaica to the cool and grassy lakes which skirt the plains of the Saskatchewan.

Baron Cuvier terminates his systematic exposition of the grallatorial order by three genera of a somewhat anomalous nature, which certainly do not amalgamate either with their neighbours or each other.

The genus CHIONIS of Forster has the bill short, strong, compressed, the nostrils tubular, and protected by hard, elevated, and compressed folds, which envelope the base. (Plate CCCC. fig. 8.) The front of the head and part of the face are naked, the wings long, the feet short. There is only a single species known. It is called the sheath-bill, *Ch. Forsteri*, or *necrophaga*, or *vaginalis*, and is of snowy whiteness, and of the size of a pigeon. A great diversity of opinion exists regarding its position; some writers removing it into the ensuing order, while Mr Swainson places it among the Columbidæ. It inhabits New Zealand, Kerguelen's Land, Staten Land, and other countries of the southern hemisphere, where it is said to frequent the seashore in flocks, feeding on mollusca and carrion, which latter renders its flesh offensive to the taste. It was discovered during Cook's circumnavigation.

The genus GLAREOLA, Gmel., contains the pratincoles, or sea-partridges as they are sometimes called. The bill is short, compressed, somewhat arched throughout, and rather deeply cleft. The wings are of great length, and very sharp pointed, somewhat resembling those of swallows. The legs are of medium length, and there is a slight palmation between the outer and middle toes. The tail is usually forked. These birds fly in numerous noisy flocks, and feed on insects, "particulièrement des mouches et autres insectes ailés qui vivent parmi les joncs et les roseaux; il se lance" (M. Temminck alludes particularly to the European species) "sur ces insectes avec une rapidité étonnante, et les saisit au vol ou à la course."[1] The pratincoles inhabit the temperate and warmer regions of the old world, and are unknown in America. The collared or Austrian species (*G. torquata*, Meyer) is common in the south-eastern countries of Europe, and has been killed occasionally in Britain.[2] *G. lactea*, Temm., inhabits Bengal;[3] *G. grallaria* of the same author is native to New Holland.

Lastly, the genus PHŒNICOPTERUS, Linn., contains those extraordinary birds called flamingoes. The bill is higher than wide, dentated, conical towards the point, the upper mandible suddenly bent from its centre downwards upon the under one, which is the broadest. The neck and legs are of extraordinary length, and the anterior toes are united by a broad palmation. Mr Swainson regards this genus as the grallatorial type of the *Anatidæ*, and he consequently places it in the natatorial order, which we are just about to enter. The only species known in Europe is *Ph. ruber*, Linn., a bird well known in Sicily and Calabria, and very abundant in Sardinia, especially among the lagunes and marshes in the neighbourhood of Cagliari. Large flocks occur almost every year along the southern coasts of France, and a few sometimes stray as far northwards as the banks of the Rhine. It is common in many countries of Africa and Asia; but the American species, regarded as synonymous by Wilson, is a distinct kind, mentioned long ago as such by Molina. (See Plate CCCC. fig. 9.) It is the *Ph. Americanus* of Mr Nuttall, and the bird alluded to by Thomas Campbell in his Gertrude of Wyoming:—

> Then, where of Indian hills the daylight takes
> His leave, how might you the flamingo see
> Disporting like a meteor on the lakes.

Palmipedes.

Another western kind occurs in South America (*Ph. ignipalliatus*, Isid. Geoff.),[4] while a fourth (*Ph. minor*) is native to the Cape and Senegal.[5] These birds in general inhabit solitary sea-coasts in most of the warmer regions of the earth, where they associate in flocks, and migrate in bodies formed into an angular phalanx, like wild geese. They feed upon mollusca, insects, and spawn, which they fish up by means of their lengthened necks, sometimes turning their bill upside down, to take advantage of its peculiar, and apparently inconvenient form. They are said to be extremely shy and watchful (although Dampier and his two companions succeeded in killing fourteen at once[6]), and place sentinels, which on the approach of threatened danger, give alarm by a loud and trumpet-like cry. They also breed together in inundated marshes, raising their nests to a considerable height, by collecting the mud into a pyramidal hillock with their toes, after which they brood and hatch their eggs in what may be called a standing posture, their feet and legs being often in the water. The young are only two or three in number, and run almost as soon as excluded from the shell. They sleep standing upon one leg, with the neck folded back upon the body, and the head reclined beneath the wing. They run swiftly, but never swim from choice.[7] The tongue of the European flamingo was much admired by ancient epicures; and Apicius, that "deepest abyss of wastefulness," as Pliny calls him, is supposed to have been the first to discover its exquisite flavour.[8]

ORDER VI.—PALMIPEDES, OR WEB-FOOTED BIRDS.[9]

The birds of this order are especially characterized by their peculiar adaptation for swimming, their feet being generally short and placed far behind, their tarsi short and compressed, and their anterior toes connected by membranes,

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[1] *Manuel*, ii. p. 502.
[2] Bullock, in *Linn. Trans.* xi. 177.
[3] See *Planches Col.* 399;—also Leach in *Linn. Trans.* xiii. pl. 12.
[4] *Annal. des Sciences Nat.* xvii. 454.
[5] Temminck, *Pl. Col.* 419.
[6] *Voyage*, i. 70.
[7] Nuttall's *Manual*, ii. 70.
[8] On concluding this portion of our present treatise, domestic circumstances, with which it does not concern the reader to become acquainted, but which the author could not control, rendered impossible the continuance of his own labour. The sketch of the ensuing (natatorial) order was therefore kindly undertaken by Mr Macgillivray, whose well-known acquirements in Ornithology will render the substitution advantageous to the public.
[9] NATATORES, Illiger.

Palmipedes.

or inlayed by lateral lobes. Their plumage is close, often glossy, and imbued with an oily fluid, which repels the water; and their skin is moreover covered with a dense layer of down, which prevents the rapid escape of the heat generated in their bodies. They are the only birds whose neck exceeds their legs in length, the reason of which arrangement is, that while swimming on the surface of the water they have often to search for their food at some depth. Their sternum is elongated so as to cover the greater part of the viscera, and has only a lateral notch, or oval foramen, so that a large surface is afforded for the insertion of the pectoral muscles. Their œsophagus is always wide, their gizzard generally muscular, and their intestine furnished with two rather long cæca. Their windpipe varies in form, but the inferior larynx is simple, although in one family it has a curious bony and cartilaginous dilatation.

This order has been divided into four families:

1. The *Brachypteræ*, or short-winged sea-birds, having the wings very short, and the feet placed so far behind that they are obliged to assume a nearly erect posture when on shore.

2. The *Longipennæ*, or long-winged sea birds, having the wings extremely long, the hind toe free or wanting, and the bill horny.

3. The *Totipalmæ*, of which the hind toe is connected with the rest by a common web, the wings long, and the bill horny.

4. The *Lamellirostres*, whose bill, which is thick and covered with a soft skin, has the edges furnished with transverse horny plates or teeth.[1]

FAMILY I.—BRACHYPTERÆ, OR DIVERS.

The organization of these birds renders them more aquatic than those of any other family. Many of them reside almost entirely on the waters, fly little, and walk with difficulty, their feet being placed very far behind. Their wings are generally extremely short, and their flight, although sometimes rapid, is neither undulated nor buoyant. In some species they are reduced to mere organs of natation, the quills not being developed. All the species are furnished with a dense and short plumage, swim and dive with remarkable agility, and pursue their prey under the surface, employing their wings as well as their feet to aid their progress. They are generally distributed, migrate extensively, and breed in society, often on rocky islands or abrupt cliffs. This family may be divided into three tribes.

1*st*. The divers,—*Colymbidæ*, are characterized by their straight, compressed, pointed, smooth bill, linear and lateral nostrils, narrow wings, and short tail. In some the feet are lobed, in others webbed.

The grebes, genus Podiceps (Plate CCCCI. fig. 1), resemble the coots in the form of their feet, their anterior toes, instead of being connected by webs, being merely dilated by means of lateral lobes. Their body is generally short and depressed; their neck long and slender; their bill straight, compressed, tapering, and pointed; their nostrils linear and pervious. The legs (tibiæ) are entirely concealed in the abdomen; the tarsi are extremely compressed; and the claw of the middle toe is flattened and dilated. The plumage is remarkably soft, silky, and often, especially on the lower part, has a shining gloss. Their wings are very narrow, and their tail is generally reduced to a slight tuft of scarcely distinguishable feathers. These birds when on shore are obliged to stand in a nearly erect posture; but although they walk with difficulty, their flight is rapid, and their motions on the water extremely quick. They dive and pursue their way under water with extreme agility, and when apprehensive of danger generally disappear under the surface, instead of flying off. Their food consists of small fishes, crustacea, mollusca, and insects, as well as seeds of aquatic plants; and they nestle in marshy places, laying several eggs, generally of a white colour. Their plumage varies so much, according to age and sex, that the species have been erroneously multiplied by authors. Four species inhabit Europe, of which two may be particularly mentioned.

The great crested grebe, *Podiceps cristatus*, is of the size of a mallard, blackish brown on the upper parts, with a white band on the wing, and of a silvery white beneath. The adults have a double black crest, and a large reddish ruff or tippet margined with black, on the upper part of the neck. This species inhabits the northern part of both continents, where it breeds, and whence it migrates southward on the approach of winter. The nest is made of rushes and flags, or other aquatic herbage; and the eggs, three or four in number, are of a greenish white. Several authors allege that the female sometimes succours her young, when fatigued or in danger, by carrying them on her back or beneath her wings. From their surprising agility in diving they are not inappropriately named water-witches and dippers in America. The skins are dressed and made into muffs and tippets.

The little grebe, or dobchick, *Podiceps minor*, is the smallest of the species, not exceeding ten inches in length. It is not uncommon in most parts of Europe, as well as in the north of Asia, and the country around Hudson's Bay. In large rivers and lakes individuals are said to be sometimes devoured by pike and other fishes. In the adult the upper parts are deep black, the lower silvery gray, the throat black, and the neck ferruginous.

The finfoots, Podoa, Illig., have the feet lobed like the coots and grebes; but their tail is more developed, and their claws more pointed. (Plate CCCCI. fig. 2.) To this genus have been referred the African finfoot, *P. Senegalensis*, and the Surinam species, *P. Surinamensis*, which latter, however, is by some considered as belonging to *Anhinga*.

The divers properly so called, genus Colymbus, greatly resemble the grebes in form, but differ from them in having the toes regularly webbed, and the tail moderately developed. Their body is elongated, and somewhat depressed; their neck long, their head small, oblong, and compressed; their bill rather long, straight, and tapering to a point; their plumage short and close; their wings of moderate length, but very narrow. These birds are peculiarly aquatic, and while in search of food remain often longer submerged than on the surface, to which they seem occasionally to come merely for the purpose of respiring. They feed on fishes of various kinds, but generally of small size, as well as on crustacea. Like the grebes, they dive when alarmed, and are not easily raised from the water, although their flight, which is direct, is very rapid. On land they stand erect, and walk with difficulty. They are generally solitary, breed on the margins of lakes in the arctic regions, and lay two or three very elongated, dark-coloured, and spotted eggs. Their flesh is dark-coloured and unsavoury. Of this genus the more remarkable species are the following.

The great northern diver, *Colymbus glacialis*, is about two feet and three quarters long, with the upper parts black, spotted with white; the head and neck glossy black, with green reflections, the lower parts white; the tail has twenty feathers. This species is generally distributed in

[1] For some interesting general observations on certain genera of this order, the reader may consult "Remarks on the Pelagic Birds, and on certain other Palmipedes, considered especially as regards their habits and their geographical distribution in the Oceans of the Globe," published in Freycinet's *Voyage autour du Monde,—Partie Zoologique*, par MM. Quoy and Gaimard.

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the cold and temperate climates of the northern hemisphere. It breeds in the arctic regions, generally on the margin of lakes, or on islands, laying three eggs of a dull olive tint spotted with dusky. "Far out at sea in winter," says Nuttall, "and in the great western lakes, particularly Huron and Michigan, in summer, I have often heard, on a fine calm morning, the sad and wolfish call of the solitary loon, which like a dismal echo seems slowly to invade the ear, and rising as it proceeds, dies away in the air. This boding sound to mariners, supposed to be indicative of a storm, may be heard sometimes for two or three miles, when the bird itself is invisible, or reduced almost to a speck in the distance. The aborigines, nearly as superstitious as sailors, dislike to hear the cry of the loon, considering the bird, from its shy and extraordinary habits, as a sort of supernatural being. By the Norwegians its long-drawn howl is, with more appearance of reason, supposed to portend rain." The flesh of this bird is dark and unpalatable; but its skin, with the feathers on, is used by various barbarous tribes as an article of clothing.

Two other species, of inferior size, the red-throated diver, *C. septentrionalis*, and the black-throated, *C. arcticus*, inhabit the same regions, and are nearly similar in habits. Both these birds breed in some of the northern parts of Scotland.

The guillemots, genus URIA, have the bill of moderate length, robust, straight, compressed, and pointed; the nostrils nearly basal, lateral, linear, and partially covered by short feathers. The head is rather large and oblong, the neck short. The legs are placed far back, and their feet differ from those of the divers in wanting the hind toe. Their wings are short, narrow, and pointed; but they fly with considerable speed, and their tail is very short and rounded. These birds migrate in small flocks, and collect in vast assemblages to breed on the abrupt precipices and rocky islands of the northern seas, whence they again retire towards the end of autumn. They form no nest, but deposit their single egg, which is pyriform and of great size, on the bare rock.

The common guillemot, *Uria troile*, is somewhat less than the mallard, and has the bill longer than the head; its upper parts are black, the lower white, as are the tips of the secondary quills; in summer the head is brown, and the adult has a black stripe behind the eye. This species is very abundant along the northern coasts of Europe and America, and nowhere more so than in the British seas.

Another species, about the same size, but distinguishable by having the bill shorter and much more robust, is the thick-billed guillemot, *Uria Brunnichii*, which also occurs in the northern seas of both continents, but does not extend so far south as the former.

The Greenland dove, or little guillemot of authors, has been considered by some as constituting a distinct genus, to which Cuvier has given the name of CEPHUS. It is about the size of a large pigeon, and is entirely black, excepting a large white space on the middle of the wing, and the feet, which are red. This species, unlike those mentioned above, breeds under stones or in the crevices of rocks, where it lays two or three light-coloured eggs, spotted with dusky. It is frequent in the northern seas, and breeds on the Scottish coasts in great numbers.

2*d*. The auks,—*Alcadæ*, which form the next group, are very closely allied to the guillemots, from which they are easily distinguished by their extremely compressed and vertically elevated bill, which is usually transversely furrowed. The toes are entirely webbed, but the hind toe is wanting, as in the guillemots, which they further resemble in their habits and distribution. This tribe may be divided into several subordinate genera.

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The puffins, genus FRATERCULA, have the bill shorter than the head, and as high at the base as it is long, a circumstance which gives these birds an extraordinary appearance, and has given rise to the appellations of coulternebs and parrot-bills, vulgarly applied to them. At the base of the bill there is generally an elevated fold of bare skin; and the nostrils, which are close to the margin, are mere slits. The puffins fly with rapidity, in a direct line, at the height of only a few feet over the waves; swim and dive with extreme dexterity; and nestle in the crevices of rocks, or more generally in holes formed by themselves in the turf.

The species best known and most extensively distributed is the common puffin, *Fratercula arctica*, which is of the size of a pigeon or jackdaw, with the upper parts dusky, the lower white, a broad black band round the neck, the bill red, with three grooves across each mandible. It is abundant on the northern coasts of Europe and America, where it breeds in burrows formed by itself in the soil of unfrequented islands and headlands, making no proper nest, and laying a single whitish and pyriform egg.

Another species, having a still more singular appearance, on account of two tufts of silky feathers on its head, inhabits the shores of Kamtschatka, the Kurile Isles, and others lying between Asia and America. The skins are employed by the natives as an article of clothing.

Some species having the bill less elevated, somewhat quadrangular, and notched near the tip, have been distinguished by M. Temminck under the generic name of PHALERIS. Of these may be mentioned the *Ph. psittacula*, and *Ph. cristatella*, both inhabitants of the north-western coast of America, Kamtschatka, and the Kurile Isles.

The auks properly so called, or restricted genus ALCA, have the bill more elongated, and in shape somewhat resembling the blade of a common pocket-knife, its base being feathered as far as the nostrils. As an example of the errors into which persons little conversant with living birds may fall, may be adduced the following statement of Cuvier with regard to the auks: "Their wings are decidedly too small to sustain them, and they do not fly at all." So far is this from being the case with our common species, that it flies with as much celerity as the guillemot and puffin, and in its ordinary flight outstrips the gulls and terns, although these birds fly with greater buoyancy. The statement, however, is correct as applying to the great auk, which might perhaps with propriety be referred to a separate genus.

The species so common on our coasts, as well as on those of Europe and North America, is the razor-billed auk, *Alca torda*, which is about the size of the common guillemot, and similarly coloured, being black above and white beneath, with a white band on the wing, and a line or two of the same colour on the bill.

The great auk, *Alca impennis*, is the largest bird of this family, equalling a goose in size. Its colour is similar to that of the common species; but its bill, which is marked with eight or ten grooves, is entirely black, and it has an oval white spot between the bill and the eye. Its wings are reduced to a kind of paddles, and are similar to those of the penguins, so that it does not possess the faculty of flying. It inhabits the highest latitudes of the globe, but is extremely rare, so that specimens are of very unfrequent occurrence in collections, and the only one in this country is that of the British Museum. A few instances have occurred of its being seen on the northern coasts of Scotland. In the northern seas this remarkable bird seems to represent the species of the next group, which belong to the other extremity of the globe.

3*d*. The penguins,—*Aptenodidæ*, are entirely destitute of the faculty of flying, their wings being converted into small, oblong, flattened paddles or fins, covered with mi-

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nute scale-like feathers. Their body is elliptical and depressed, their neck of moderate length, their head oblong, their bill of moderate length, generally slender and pointed, the upper mandible covered with feathers for a third of its length, or as far as the nostrils, whence a groove extends to the tip. Their legs are very short, and placed so far behind that they cannot support themselves on land, even in a vertical position, without resting on their tarsi, which are flattened behind, somewhat like the foot of a quadruped. Their life is chiefly spent on the ocean, and as they possess the faculties of swimming and diving in the highest degree of perfection, they are the most truly aquatic of all birds, and the analogues of the swallows, which are the most aërial. If any bird approaches nearly in structure and habits to a quadruped, the penguins may claim kindred with the seals, which they greatly resemble in their mode of life, going on shore merely to breed, and dragging themselves over the rocks in a similar manner.

The penguins peculiarly so named, genus APTENODYTES, as restricted, have the bill rather long, slender, and pointed, the upper mandible slightly arched towards the end, and covered with feathers at the base; the nostrils linear, with the nasal groove extending to the tip.

The Patagonian or great penguin, *Aptenodytes Patagonica* (Plate CCCCI. fig. 4), is nearly of the size of the great auk, of a dark-grayish blue above, white beneath, the head black, and a yellow curved band on the fore neck. It occurs in great flocks on the coasts of the Falkland Isles, New Guinea, New George, the Straits of Magellan, and other antarctic lands; feeds on fish, crustacea, and mollusca; and is employed by the natives as an article of food, although its flesh is dark-coloured and rank.

The gorfous, genus CHRYSOCOMA, have the bill short, strong, and somewhat conical, with the point a little arched. (Plate CCCCI. fig. 3 *b*.) The groove from the nostril ends about a third from the tip. In other respects they do not differ materially from the penguins.

The leaping gorfou, *Chrysocoma saltator*, is a handsome bird, of the size of a domestic duck, with the head and upper parts grayish black, the lower white, and the head ornamented with a large crest, of which the central part is erect and dusky, the lateral portions deflected, and of a yellow colour. It is common in the Falkland Islands and other parts of the southern seas; and, like the Patagonian penguin and other birds of this group, is said to be so stupid as to allow itself to be assailed without attempting to escape. It is extremely expert at diving; and like several birds of different families, such as the cormorants and darters, is often observed, while about to plunge beneath the surface, to leap several feet out of the water,—whence our sailors have named it the hopping penguin, or jumping Jack. The word gorfou is a corruption of goir-fugel, or gare-fowl, applied in Ferroe and the north of Scotland to the great auk, *Alca impennis*.

Several other species of this genus are known, and inhabit the same seas, such as the Papuan gorfou, *Chr. Papua*; the collared, *Chr. torquata*; the red-footed, *Chr. catarractes*; and the little gorfou, *Chr. minor*.

The sphenisques, genus SPHENISCUS, form a group characterized by their straight, compressed bill, which is irregularly grooved at the base, and has the tip of the upper mandible curved, while that of the lower is obliquely truncate, as in the cormorant. (Plate CCCCI. fig. 3 *a*.)

The Cape sphenisque, *Spheniscus demersus*, is about twenty inches long, black above, white beneath, with the throat and cheeks black, a white line over each eye, and a black band across the fore part of the neck, and extending along each side of the body. It occurs in the vicinity of the Cape of Good Hope, where it nestles in the rocks.

Another species, *Spheniscus Magellanicus*, upwards of two feet long, with the upper parts, a band on the breast, and a collar on the middle of the neck, black, inhabits Terra del Fuego, the Straits of Magellan, and other parts of the antarctic regions, where they are very numerous. This species, like the gorfou, and probably all the birds of this tribe, has a habit of leaping several feet out of the water, either when about to dive, or when it meets with any obstacle on the surface.

FAMILY II.—LONGIPENNÆ.

To this family belong those wandering sea-birds which, having a flight characterized by extreme buoyancy and rapidity combined, are met with on all parts of the ocean, frequently at the greatest distance from land. Their wings are always very long, although often extremely narrow; and their tail is proportionally developed. Their hind toe is small and free, or wanting; their bill pointed or hooked at the tip, but without lamellæ; their inferior larynx has only one muscle on each side; their œsophagus is wide, their stomach muscular, their cæca short. They are incapable of diving and pursuing their prey under the surface, but they swim with ease, and sit lightly and gracefully on the water. Some of them obtain their food by dipping or plunging from on wing, others by picking it up as they swim, while several wander to great distances in quest of dead animals of all kinds, and are in fact the vultures of the sea.

The petrels, *Procellariæ*, have their bill hooked at the tip, which seems as if formed of a separate piece articulated to the rest (Plate CCCCI. figs. 5, 6, and 9); their nostrils placed close together, and enclosed by a tube which lies on the back of the upper mandible; and their hind toe reduced to a knob with a claw upon it. These birds, although many of them are very small, reside on the open ocean, where they are met with by voyagers in the most tempestuous as in the calmest weather. Their food consists of small fishes, crustacea, and especially oily substances of all kinds; and most of them when seized, whether on being wounded or on being dragged from their holes, disgorge an oleaginous matter, or squirt it through their nostrils. They are incapable of diving, and seldom swim, but are generally seen flying or gliding over the surface of the waves, mounting upon their ridges and descending into the hollows, often so close as to seem walking on the water. Hence the name Petrel, or Little Peter, bestowed upon them, in allusion to St Peter's progress on the waves. In stormy weather they frequently fly in the wake of a ship, to shelter themselves from the wind. On account of this habit they are held in aversion by sailors, who, imagining them to be predictive of tempests, and in league with the mysterious source of evil, bestow on them the opprobrious appellation of Mother Carey's chickens. Their flight is rapid and buoyant; they breed in holes and crevices of the rocky coasts; and are more numerous in the antarctic than in the northern seas.

Those which have the lower mandible truncate are more peculiarly named petrels, genus PROCELLARIA.

Of these the largest is the giant petrel, *Procellaria gigantea*, which has a length of about three feet and a half, and is of a dusky colour above, whitish beneath, with the bill and legs yellow. It is of frequent occurrence in the southern seas, is observed to be most lively in stormy weather, and feeds on fishes, and the carcasses of seals, birds, and other animals.

The pintado, or Cape petrel, *Procellaria Capensis*, is about fourteen inches long, variegated with brown and white, and occurs in large flocks in the antarctic seas, particularly in the vicinity of the Cape of Good Hope. Like most of the other species, it flies very low, feeds on fish

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and the carcasses of cetaceous animals, and when caught squirts out a quantity of oil from the nostrils.

In the arctic seas a very abundant species is the fulmar petrel, *Procellaria glacialis*, which is nearly of the size of the herring gull, and has the upper parts of a light bluish-gray, the head and lower parts white. It is extremely voracious, and although its principal food consists of fish, it devours indiscriminately any floating animal substance, and follows in flocks the track of a wounded whale, until the huge animal is exhausted, when it alights on the carcass, and devours the blubber until satiated. This bird is one of those most familiar to the sailors of the whale-ships, on which it constantly attends, to pick up any offal that is thrown overboard, and come in for its share of the plunder when a whale has been captured. It breeds abundantly in the island of St Kilda, the inhabitants of which obtain a large quantity of oil from the stomachs of the individuals which they catch for that purpose.

Of the smaller dark-coloured species may be mentioned the common or storm petrel, *P. pelagica*, which is not larger than a lark, and in its flight resembles a swallow (Plate CCCCI. fig. 5); Leach's petrel, *P. Leachii;* and Wilson's petrel, *P. Wilsonii*. Respecting the latter, we may quote the following passage from the description given of it by M. Audubon, in his *Ornithological Biography*. "But now, ever flapping its winglets, I have marked the little bird, dusky all over save a single spot, the whiteness of which contrasts with the dark hue of the waters, and the deep tone of the clear sky. Full of life and joy, it moves to and fro, advances towards the ship, then shoots far away, gambols over the swelling waves, dives into their hollows, and twitters with delight as it perceives an object that will alleviate its hunger. Never fatigued, the tiny petrels seldom alight, although at times their frail legs and feet seem to touch the crest of the foaming wave. I love to give every creature all the pleasure I can confer upon it, and towards the little things I cast over the stern such objects as I know they will most prize. Social creatures! would that all were as innocent as you! There are no bickerings, no jealousies, among you; the first that comes is first served: it is all the result of chance; and thus you pass your lives. But the clouds gather, the gale approaches, and our gallant bark is trimmed. Darkness spreads over the heavens, and the deep waters send back a blacker gloom, broken at intervals by the glimmer of the spray. You meet the blast, and your little wings bear you up against it for a while; but you cannot encounter the full force of the tempest; and now you have all come close beneath me, where you glide over the curling eddies caused by the motion of the rudder. You shall have all possible attention paid you, and I will crawl to the camboose, in search of food to support your tiny frames in this hour of need. But at length night closes around, and I bid you farewell....The gale is over; the clear blue of the sky looks clearer than ever, the sun's rays are brighter, on the quiet waters the ship seems to settle in repose, and her wings, though widely spread, no longer swell with the breeze. At a distance around us the dusky wanderers are enjoying the bright morning; the rudder-fish, yesterday so lively, has ended its career, so violently was it beaten by the waves against the vessel; and now the petrels gather around it, as it floats on the surface. Various other matter they find; here a small crab, there the fragments of a sea-plant. Low over the deep they range, and now with little steps run on the waters. Few are their notes, but great their pleasure, at this moment. It is needless for me to feed them now, and therefore I will return to my task."

The puffin-petrels, genus PUFFINUS, are separated from the rest on account of their having the extremity of the lower mandible decurved as well as that of the upper, and the nostrils opening, not by a common orifice, but by two distinct apertures. (Plate CCCCI. fig. 9.)

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Of this genus may be mentioned the cinereous puffin-petrel, *Puffinus cinereus;* the Manks petrel, *Pr. anglorum;* and the dusky petrel, *Pr. obscura*.

In the genus HALADROMA of Illiger, the throat is dilatable like that of the cormorants, and the hind toe is entirely wanting as in the albatrosses. In the genus PACHYPTILA of the same author, the bill is enlarged at the base, and its margins are garnished interiorly with fine delicately-pointed vertical lamellæ. (See Plate CCCCI. fig. 6.)

The albatrosses, genus DIOMEDEA, are the largest and most powerful of all the feathered wanderers of the ocean. Their bill, which is large, strong, and sharp-edged, is terminated by a strong hook; their nostrils, which are tubular, are placed apart; and their feet are destitute of the hind toe. Their plumage is full, soft, and elastic, and their wings, although narrow, are exceedingly long. They are thus equally organized for swimming and flying, and are met with in all parts of the intra-tropical and southern oceans, sometimes following a ship in full sail for many days, to pick up the refuse thrown overboard. They fly with surprising buoyancy and speed, and are able to bear up against the most violent tempests. When fatigued or satiated they rest upon the waters. Their food consists of the carcasses of all sorts of animals, as well as live fishes, crustacea, mollusca, and other creatures, and their voracity is such that sometimes having gorged themselves to excess, they are unable for a time to fly, and may be caught or destroyed. Under these circumstances, however, birds generally disgorge the contents of their gullet and stomach, and by thus lightening themselves, are enabled to escape.

Of the different species of this genus, that which is the best known, as well as the largest, is the wandering albatross, *Diomedea exulans*. It is as large as a swan, being four feet in length, and measuring ten feet between the tips of its extended wings; its upper parts dusky, the lower white, the neck and sides transversely streaked with brown, the primary quills black, the bill yellowish white, the feet flesh-colour. This celebrated bird is principally met with in the seas adjacent to the Cape of Good Hope, and in those that separate the American continent from the Asiatic. It is extremely voracious, feeding on fishes, mollusca, and the carcasses of whales and other animals It is said that when it cannot swallow a large fish at once, it introduces part of it, and waits until it is digested before swallowing the rest. Its flesh, although hard and dry, is eaten by the inhabitants of Kamtschatka, who use its bones for tobacco-pipes and needle-cases.

From the albatrosses to the larger birds of the next genus the transition is but slight, both as regards form and habits.

The gulls, genus LARUS, Plate CCCCI. fig. 8, constitute an extensive group, of which representatives are found in all parts of the globe. They are characterized by their longish, compressed bill, of which the upper mandible is arched towards the end, while the lower is there furnished with an angular prominence. The nostrils, which are placed near the middle, are linear-oblong and pervious. Their body is generally light, the neck of moderate length, their head ovate and rather large, their legs of ordinary length, and their hind toe very small, or sometimes obsolete. Some of the species are met with in the open ocean, but it is chiefly along the coasts, and especially near the mouths of rivers, that they are most frequently seen, and in stormy weather they often make incursions over the land in search of worms, larvæ, and carrion. Their food consists chiefly of small fishes, crustacea, and mollusca; but to the larger species hardly

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any animal substance comes amiss. They breed along the shores, on unfrequented islands and headlands, laying in a hollow on the ground from two to four eggs, spotted with dusky.

Among the larger species, some are remarkable for the dark or blackish hue of their back and wings; but in general the colour of those parts is a light-grayish blue, while that of the lower is pure white. One species, the ivory gull, *Larus eburneus*, has the plumage entirely of the latter colour when in the adult state. The greater black-backed gull, *Larus marinus*, the smaller black-backed gull, *Larus fuscus*, and the thick-billed gull of New Holland, *Larus melanoleucos*, afford examples of the first kind above alluded to. The largest known species is the burgomaster, *Larus glaucus*, of a light-grayish blue above, white beneath, with the tail and tips of the wings also white. It inhabits the arctic regions of Europe and America, seldom making its appearance in the temperate climates. One of the most common species on our coasts is the herring gull, *Larus argentatus*, which remains with us throughout the year. A gradual transition is observable from these larger species, which assimilate to the albatrosses, to the smaller, which are intimately connected with the terns.

Some species having very peculiar characters, have been separated from the gulls, and formed into a genus apart. These are the jagers, genus Lestris, which have the tip of the upper mandible hooked, and the nostrils larger and placed nearer the end of the bill than those of the gulls. Their tail is generally pointed, their wings long, and their flight is extremely rapid. Although they occasionally fish for themselves, they obtain their food chiefly by attacking various species of gulls and terns, which they teaze to make them disgorge their food, which they then swallow.

Of this genus the more remarkable species are the skua, *Lestris catarractes*, which is nearly equal in size to the great black-backed gull; the pomarine jager, *L. pomarinus;* and Richardson's jager, *L. Richardsonii*, which is common on our coasts in autumn, and breeds in the Shetland Islands and Hebrides.

The terns, genus Sterna, are generally of small size, and remarkable for their slender body, long and narrow wings, and forked tail. Their feet are extremely short, and their bill longish, compressed, and pointed. They very seldom swim, but, when fatigued or satiated with food, repose on the rocks or sands. Their flight is extremely buoyant, and they usually obtain their food by plunging after it into the water from on wing. From their form and the peculiar mode of flying, they have also obtained the name of sea-swallows.

The most common species on the coasts of Europe are the arctic tern, *Sterna arctica;* the common tern, *St. Hirundo;* and the little tern, *St. minuta;* but several other species occur there.

The noddies, genus Anous, differ from the terns in having the tail even at the end, and nearly equal with the wings. Their bill also is more like that of the smaller gulls. They are said to be so stupid as to allow themselves to be killed without attempting to fly off; but this only happens in places where they have not been accustomed to meet with man.

The species best known is the black noddy, *Anous niger* (*Sterna stolida*, Linn.), which is very common in the tropical seas, and is of a sooty-brown, excepting the top of the head, which is grayish white. It often settles on the rigging of vessels, when the sailors sometimes catch it at night while asleep.

The skimmers, genus Rhynchops, Plate CCCCI. fig. 7, are very nearly allied to the terns, but are distinguished from all other birds by the extraordinary form of their bill, of which the upper mandible is considerably shorter than the lower, and grooved beneath, so as to receive the edge of the latter, which is extremely thin. They procure their food in the same manner as the terns, skimming along the surface of the water, and dipping their bill into it to seize a small fish, as opportunity occurs.

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The only species whose habits are known is the black skimmer, *Rhynchops nigra*, which is about twenty inches long, its bill and feet red, its upper parts black, the lower white, its wings considerably longer than the tail. It occurs along the coasts of America, from New York to Brazil, breeding on the sandy shores in June, and continuing in flocks all the year.

FAMILY III.—TOTIPALMÆ.

The birds of which this family is composed are those to which the epithet *palmipede* is more peculiarly applicable; for not only are their anterior toes connected by webs or membranes, as in the other tribes, but their hind toe is similarly connected with the inner. Their tarsi are generally short, their wings and tail long, their neck elongated, and their bill rather slender, somewhat conical, but generally hooked at the joint. They swim, and for the most part dive, with admirable dexterity, generally fly with great celerity, feed entirely on fishes and other marine animals, and are remarkable among web-footed birds for frequently perching on trees.

The pelicans, *Pelecani*, comprehend those which have at the base of the bill a space destitute of feathers. The skin of their throat is extensile, their tongue very small, their gullet of great width, their cæca small, their nostrils mere slits, sometimes obsolete.

The pelicans properly so called, genus Pelecanus, Plate CCCCI. fig. 10, are distinguished from all other birds by the singular structure of their bill, of which the upper mandible, however, presents nothing very remarkable, while the lower has its rami extremely slender and elastic, with a large dilatable membranous bag attached to it. They are birds of large size, with wings of moderate length, the tail rounded, the feet short, and the claws curved.

The most remarkable species is the common pelican, *Pelecanus onocrotalus* (above referred to), which is as large as a swan, and entirely of a white colour tinged with red, excepting the alula and primary quills, which are black. Its length is nearly six feet, and its extended wings measure about fifteen. Its upper mandible is flattened, with a hook at the point; and the sac appended to the lower mandible extends about nine inches down the neck, and may be dilated so as to hold a man's head with ease. This pelican occurs in the tropical and warmer temperate regions of the old continent, and is common in the eastern countries of Europe. Its principal food is fish, which it catches with great dexterity, by plunging after it from on wing. In fishing it fills the gular pouch, and does not immediately devour its prey, but when it has obtained a sufficiency, returns to the shore, and swallows it at leisure. The female forms a large nest of grass in a marshy place, and lays two or three white eggs, similar to those of a swan.

The brown pelican, *P. fuscus*, of a grayish-brown colour, and nearly four feet in length, is common in most parts of America, and especially in the West Indies. A very large species, *P. australis*, of a white colour, with the upper part of the back, the quills, and tail, black, inhabits New Holland.

The cormorants, genus Phalacrocorax, resemble the pelicans in their general form, but are destitute of the large gular sac, having merely a bare dilatable membrane at the base of the lower mandible. They differ farther in not procuring their prey by plunging after it from

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on wing, their mode of fishing being similar to that of the divers.

The common cormorant, *Phalacrocorax carbo*, is nearly as large as a goose, and has a brownish-black colour, with a white spot on the thigh, and streaks of the same colour on the head and neck. It nestles in the cavities of rocks, or on trees, laying three pale-green eggs, crusted with white calcareous matter; and is common in the northern parts of both continents. It is stated that this species was formerly trained in England for the purpose of catching fish. "When they come to the rivers," says Willughby, "they take off their hoods, and having tied a leather thong round the lower part of their necks, that they may not swallow down the fish they catch, they throw them into the river. They presently dive under water, and there for a time, with wonderful swiftness, they pursue the fish, and when they have caught them, they rise presently to the top of the water, and pressing the fish lightly with their bills, they swallow them, till each bird hath in this manner swallowed five or six fishes; then their keepers call them to the fist, to which they readily fly, and, little by little, one after another, vomit up all their fish, a little bruised with the nip they gave them in their bills. When they have done fishing, getting the birds on some high place, they loose the string from their neck, leaving the passage to the stomach free and open; and for their reward they throw them part of the prey they have caught, to each, perchance, one or two fishes, which they by the way, as they are falling in the air, will catch most dexterously in their mouths."

A very common species on our coasts is the crested cormorant, *Phal. cristatus*, which is of a dark-greenish colour, with a recurved frontal tuft, and resembles the preceding in its habits, breeding in the rocky caverns of islands and headlands. Many other species occur in different parts of the world, the genus being generally distributed.

The frigate-birds, genus TACHYPETES, differ from the cormorants in having the tail forked, the wings extremely elongated, the feet very short, with their webs emarginate, and the tip of both mandibles decurved. Their flight is extremely rapid and buoyant, and they prey upon fishes, which they capture by plunging after them from on wing, or obtain by forcing the gannets to disgorge. Only one species is well known.

The common frigate-bird, *Tachypetes aquilus*, is of a dusky colour, more or less variegated with white on the neck, and sometimes measures ten feet between the tips of its extended wings. It inhabits the tropical regions, and is found in great abundance on the island of Ascension. Its principal food consists of flying-fishes, which it captures during their aërial excursions. The following account of this remarkable species, generally known to navigators by the name of the man-of-war, or frigate, is given by Mr Audubon. "This bird is possessed of a power of flight, which I conceive superior to that of perhaps any other bird. However swiftly the Cayenne tern, the smaller gulls, or the jager, move on wing, it seems a matter of mere sport to it to overtake any of them. The goshawk, the peregrine, and the gyr-falcon, which I conceive to be the swiftest of our hawks, are obliged to pursue their victim, should it be a green-winged teal or passenger-pigeon, at times for half a mile, at the highest pitch of their speed, before they can secure them. The bird of which I speak comes from on high with the velocity of a meteor, and on nearing the object of its pursuit, which its keen eye has spied while fishing at a distance, darts on either side to cut off all retreat, and with open bill forces it to drop or disgorge the fish which it had just caught. See him now! yonder, over the waves leaps the brilliant dolphin, as he pursues the flying-fishes, which he expects to seize the moment they drop into the water. The frigate-bird, who has marked them, closes his wings, dives towards them, and now ascending, holds one of the tiny things across its bill. Already fifty yards above the sea, he spies a porpoise in full chase, launches towards the spot, and in passing seizes the mullet that has escaped from its dreaded foe; but now, having obtained a fish too large for his gullet, he rises, munching it all the while, as if bound for the skies. Three or four of his own tribe have watched him, and observed his success. They shoot towards him on broadly extended pinions, rise in wide circles, smoothly, yet as swiftly as himself. They are now all at the same height, and each, as it overtakes him, lashes him with its wings, and tugs at his prey. See! one has fairly robbed him, but before he can secure the contested fish it drops. One of the other birds has caught it, but he is pursued by all. From bill to bill, and through the air, rapidly falls the fish, until it drops on the waters, and sinks into the deep. Whatever disappointment the hungry birds feel, they seem to deserve it all."[1]

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The boobies, or gannets, genus SULA, have the bill straight, conical, a little compressed, and with the point somewhat deflected, the edges serrate, or cut into by short parallel lines. The throat and the space around the eyes are bare; the claw of the middle toe serrate, the wings long and very narrow, and the tail cuneate or tapering. They hover over the water when fishing, and plunge headlong after their prey, resting a few moments on emerging before they resume their flight.

The common gannet or solan goose, *Sula bassana*, occurs on the coasts of Europe and North America, and breeds in vast numbers on remote and rocky islands. The Bass Rock at the entrance of the Frith of Forth is a well-known haunt of this species, as are Ailsa Craig in the Clyde, St Kilda, and Suliskerry. The nest is very bulky, and composed of sea-weeds; the single egg not larger than that of a domestic duck, and of a white colour; the young, at first covered with snow-white down, is when fledged of a dark-brown colour, spotted with white. Although the flesh of this species is rank and oily, it was formerly considered a kind of delicacy, and is still sparingly used in the south of Scotland.

The booby gannet, *Sula candida*, is inferior in size to the species just mentioned, which it closely resembles in form and habits. It is common on the coasts of the warmer parts of America, particularly in the Bahama Islands and the Brazilian seas. Although it sometimes nestles on the ground, it generally builds on trees, and reposes there at night. It is said to be a very stupid bird, allowing itself to be knocked on the head or seized, without attempting to escape,—whence the name of booby, commonly given to it by the sailors, who frequently employ it as an article of food, although its flesh is dark-coloured and disagreeable.

The darters, genus PLOTUS, resemble the cormorants in the form of their body and feet, but are more slender, and have a very elongated neck, with a small head, and a straight, slender, and pointed bill. Like the cormorants, they swim deep in the water, but with agility, and in diving spring fairly out of it to plunge headlong after their prey. They inhabit the warm countries of America.

The black-bellied darter, *Plotus melanogaster*, Plate CCCCII. fig. 1, is upwards of three feet long, of a dusky colour, with the neck and back streaked with white. The white-bellied darter, *P. anhinga*, is about the same size, but has the lower parts white. It inhabits Brazil and

[1] *Ornithological Biography.*

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other parts of America, roosting at night on trees, whence, should one approach, they drop into the water as if dead; and on emerging at a distance, show only their long slender necks and heads, which bear so much resemblance to those of serpents, that this species is frequently named the snake-bird.

The tropic birds, genus PHAETON, which form the last group of this section, bear a considerable resemblance to the gannets, but are readily distinguished by the two extremely elongated feathers of their tail, on account of which the French give them the not inappropriate name of *paille-en-queue*. Their head is entirely feathered; their bill straightish, tapering, pointed, and denticulated on the edges; their feet are short, and their wings long. The flight of these birds is rapid and buoyant, and they are often seen far out at sea. As they seldom extend their range beyond the tropics, their occurrence apprises navigators of their entrance into the warmer regions. They perch and nestle upon trees.

Two species are distinguished;—the common, or white-tailed tropic bird, *Phaeton æthereus;* and the red-tailed species, *Ph. phœnicurus*. The former is white, with the ocular region and shoulders black, the primary quills of the same colour, and the bill red. It inhabits the Atlantic Ocean. The latter is of a pale rose-colour, or reddish white, with the ocular region and wing-coverts deep black, and the two elongated feathers of the tail red. It occurs in the Indian and African Seas, at Madagascar, the Cape of Good Hope, the Isle of France, and many of the South Sea islands.

FAMILY IV.—LAMELLIROSTRES.

The birds of this family are readily distinguished from those of the preceding by the peculiar structure of the bill, which has its margins furnished with horny lamellæ, or dentiform processes, and its surface covered with soft skin, in place of the horny envelope which is spread over that of the other Palmipedes. The tongue, which is broad and fleshy, has its margins also lamellate; the gizzard is extremely muscular, although not of large capacity, and the cæca are rather long. Another remarkable distinction is found in the lower larynx, which generally has a very extraordinary dilatation in the males. Their body is usually somewhat depressed, their wings of moderate length, their feet short, and their neck more or less elongated, sometimes of extreme length. They swim with ease, but walk in a constrained and vacillating manner; and are for the most part phytophagous, though many feed on mollusca, crustacea, and fishes. They occur in all parts of the globe,—some being maritime, but the greater number lacustrine or fluviatile, that is, frequenting lakes or rivers. They are naturally arranged into two groups;—the one (*Anatidæ*) comprising the swans, geese, and ducks; the other (*Mergidæ*) composed of the mergansers.

The great group of *Anatidæ* includes all those web-footed birds which have their bill large and broad, covered with a thin membrane, and having its edges furnished with transverse or oblique lamellæ, the object of which seems to be to allow the water to escape when the bird has seized its food. Vegetable substances, especially seeds, roots, and blades of grasses, form the principal nourishment of many of the species; but others feed on fishes, mollusca, insects, and worms. The piscivorous species dive in pursuit of their prey, while those which feed on vegetable matter either procure it on shore, or along the margins of the water, or, while floating on the surface, obtain it from some depth by means of their long neck. The flesh of many of these birds is much esteemed, but is not so readily digestible as that of the waders and gallinaceous order. Many of them moult twice in the year, and after the summer change the males assume in part the colours peculiar to the females, which, on the contrary, exhibit no variation. They generally breed in marshy places, and deposit numerous eggs. The young, which are at first covered with stiffish down, are capable of walking and swimming immediately after birth.

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The characters by which the subdivisions of this group are distinguished are derived chiefly from the form of the bill. In the swan that organ is as broad at its fore part as at the base, where its height is greater than its breadth, and the nostrils are placed about the middle. In the geese, the bill is shorter than the head, higher than broad at the base, and narrower towards the end. Lastly, in the ducks properly so called, the bill is at least as broad at its extremity as at the base, where it is broader than high; the nostrils are placed on the back of the bill near the base. In the swans the neck is extremely long, in the geese of moderate length, and in the ducks generally rather short.

The *swans*, genus CYGNUS, are the largest birds of the family, and are characterized by the elegance of their form, and the graceful ease with which they glide over the surface of the water, although on land their motions are more constrained. Their body is large, their neck extremely elongated, their head oblong, their wings large, and their feet short and strong. They live chiefly on the seeds and roots of aquatic plants, and nestle among the reeds by the margins of lakes and rivers. They are strictly monogamous, and the young swim and walk immediately after exclusion.

The wild swan, *Cygnus ferus*, has the bill yellow at the base, and black towards the end, the plumage pure white, but in the young of a gray colour. It is readily distinguished from the domestic swan by having the base of the bill flattened above, and by the curvature formed by the wind-pipe, which enters into a cavity in the crest of the sternum, from which it is reflected anteriorly, and then passes into the thorax. This species inhabits the northern regions of both continents, whence it migrates southward on the approach of winter, remaining in the temperate countries until the return of spring. The female lays from five to seven or eight eggs, of a whitish colour tinged with olive, and is said to incubate six weeks. The flesh and eggs are highly esteemed, and the skins are prepared with the down to be made into garments. The down itself forms an article of commerce, which is in considerable demand in the colder countries of Europe. The song of the swan is familiar to all the lovers of poetry; but, like many equally accredited facts, has no real existence; for the cry of this bird, although clear and shrill, is never modulated into harmony. When heard at a distance, however, especially from a flock on wing, it is extremely pleasing. Another fable regarding the vast strength of wing of this bird was long believed,—a blow from it being alleged as sufficient to break a man's thigh. "It is high time," says Montagu, "such absurdities should be erased in this philosophic age, and that the mind of man should reason before he continues to relate such accounts, only calculated to frighten children. Let the bones of the wing of the swan be examined, and compared with the thigh of a man, or even of his arm, and it will be evident that it would be as impossible for a swan to break a man's arm, as it would be to break his head with a reed. The bone of a man's arm would bear a pressure fifty times as great as the bone of a swan's wing; how, then, is the inferior in size and strength to break the superior, without at least being itself fractured? It should also be recollected, that a bird is incapable of striking with any degree of force while all its quill-feathers are perfect, the resistance of the air against such a surface being too great to allow of

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its moving with sufficient velocity to inflict any sensible pain."[1]

A species very nearly allied to the above is Bewick's swan, *Cygnus Bewickii*, which was first distinguished as a species by Mr Yarrell and Mr Richard Wingate of Newcastle. It has the bill black, with its base orange yellow, the plumage white, and the tail of eighteen feathers, whereas there are twenty in that of the common wild swan. The curvature of the trachea is also different, and the size of the species is about a third smaller. It inhabits the arctic regions of both continents, migrating southward in winter.

The mute or tame swan, *Cygnus olor*, has the bill red, its edges, the nail at its tip, and a large knob at the base of the upper mandible, black; the plumage white, the tail of twenty-four feathers. In this species the trachea has no extra thoracic curvature. The tame swan is said to be found in its wild state in the eastern countries of Europe and Asia. It is generally distributed over Europe in a domesticated state, forming a great ornament to our rivers and artificial pieces of water. It makes its nest of grass, among reeds, and deposits seven or eight eggs of a greenish-white colour, which are hatched in seven or eight weeks. The young are of a gray colour, and were formerly much esteemed as an article of food.

The black swan, *Cygnus atratus*, of which the general colour of the plumage is brownish black, with part of the wings white, and the bill red, inhabits various parts of New Holland, and is now not uncommon in a domesticated state in this country. (See Plate CCCCII. fig. 5.)

Intermediate between the swans and geese are several species, such as the Guinea goose, *Anas cygnoides* of Linnæus, and the spur-winged or Gambia goose, *Anas Gambensis* of the same author,—which, although less elegant than the swans, are yet nearly allied to them in the form of their bill.

The *geese*, genus Anser, are distinguished, as has been already said, by the form of their bill, which is short, and narrowed towards the point. Their feet are also proportionally longer than those of the ducks, so that they have a greater facility in walking. They swim less, however, and are incapable of diving. They live in flocks, feed on gramineous plants and seeds, migrate in large bodies, which during their flight are usually disposed in divergent lines, and breed in marshy places, laying numerous eggs. Those species which have the bill more slender and somewhat cylindrical, are separated by some authors to form the genus Bernicla. Three species of geese properly so called, and two of bernicles, are not uncommon during winter in this and other countries of Europe.

That to which the origin of the domestic goose is attributed, the gray lag, or common wild goose, *Anser ferus*, is nearly three feet long, with the bill large and of an orange colour, the feet flesh-coloured, and the plumage light gray and clove brown; the rump and lower parts white. It was formerly very abundant in this country, where it resided all the year, but is now met with only in small flocks in the winter season, although a few individuals have recently been found to breed in the north of Scotland—for example, in the islets of the lochs of Sutherland.

The bean goose, *Anser segetum*, is a little smaller, with the bill more elongated, and of an orange colour, with its base and the nail black; the upper part ash-gray tinged with brown, the rump dark brown, the abdomen and lower tail-coverts white. This species is much more plentiful with us than the last, appearing in large flocks in November, and retiring northward in April and May.

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The white-fronted goose, *Anser albifrons*, has the bill and legs orange, the plumage gray on the upper parts, on the lower white, and a patch of the same colour on the forehead.

The common bernicle, *Anser leucopsis*, which has the forehead, cheeks, and throat white, with the crown of the head, the neck, and the breast black, is not unfrequent on the western coast of Britain in winter; and the brent goose, *Anser torquatus*, characterized by having the head, neck, and breast black, with a white patch on each side of the neck, is also common in many parts, especially along our eastern shores. The former of these species was long believed, even by the learned, to be the produce of a species of cirripodous animal, the *Lepas anatifera* of Linnæus, the long feather-like branchiæ of which gave rise to this absurd fable.

Another species of bernicle was observed, on Captain Parry's second voyage, on Melville Peninsula, and named by Dr Richardson, in the *Fauna Boreali-Americana*, in honour of Mr Hutchins, from whom Pennant and Latham derived most of their information respecting the birds of Hudson's Bay. It is about twenty-five inches in length, with a very short black bill; the head, neck, rump, and tail pitch-black, and a white kidney-shaped patch upon the throat.

From the bernicles and geese some authors distinguish, under the generic name of spurwing, Chenalopex, the species usually named the Egyptian goose, which has the bill longer than the bernicles, and has the wings armed with a spur upon the bend. It inhabits various parts of Africa, especially Egypt and the Cape of Good Hope, whence it has been introduced into this country.

The next genus, Cereopsis, is formed by a New Holland species, resembling the bernicles in form, but with the bill smaller, and having at its base a membrane extending over the forehead. The palmation of the feet is not so full as usual.[2] (Plate CCCCII. fig. 2.)

The *ducks*, properly so called, have the legs much shorter than the geese, and placed farther back, the neck shorter, and the body more depressed. Their trachea also has a large dilatation at its bifurcation.

Some of them, having the hind toe margined with a membrane or lobe, the tarsi more compressed, the head larger, and the wings shorter, feed on fishes and other aquatic animals, and are less expert at walking, but dive with greater agility. These species have been variously grouped by authors into numerous genera, of which the following are among the more remarkable.

The *scoters*, genus Oidemia, have the bill short and broad, with an elevated tumour or knob at the base, but towards the tip much depressed and flattened, the nail obtuse and roundish; the lamellæ widely set, and scarcely projecting; the nostrils oval and sub-medial, the tail short and graduated.

To this genus belong the velvet scoter, *Oidemia fusca*; the black scoter, *O. nigra*; and the surf scoter, *O. perspicillata*; which occur along the coasts of the northern temperate regions in winter, feeding on fishes, and especially mussels and other testaceous mollusca. Like that of the other sea-ducks, their flesh is held in little estimation, being dark-coloured and tough, with a fishy flavour.

The *garrots*, genus Clangula, have the bill shorter than the head, elevated at the base, narrowed towards the end; the lamellæ numerous, but not projecting; the nostrils roundish, and medial; the tail of moderate length, and graduated.

The golden-eye, *Clangula chrysophthalma*, which is white, with the head, the back, and the tail black, a small

[1] *Ornithological Dictionary.*

[2] For the history of the only known species, *Cer. Novæ Hollandiæ*, see *Zoological Gardens*, vol. ii. p. 315.

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spot before the eye, and two bands on the wing, white, breeds in the arctic regions of both continents, and appears on the estuaries and lakes of the more temperate countries in winter. The female is of a gray colour, with the head brown.

To this genus belongs the harlequin-duck, *Clangula histrionica* (Plate CCCCII. fig. 3), which is distinguished by having a large patch of white on the lore, a spot on the ear, a longitudinal band on the sides of the neck, a transverse band on the neck, and another on each side of the breast, white; with the speculum or wing-spot blue, and the legs dusky. It derives its name from the singularity of its markings, and inhabits the northern parts of both continents.

The *pochards*, genus FULIGULA, have the bill as long as the head, broad and much depressed anteriorly, and a little dilated towards the tip; the upper lamellæ not projecting beyond the margin; the nostrils oblong, sub-basal; the wings and tail short, the latter rounded. This section contains a great number of species, most of which are maritime and piscivorous, although the flesh of many is considered palatable, and that of one, the canvass-backed duck, has been celebrated by the epicures of the western world.

The red-headed pochard, *Fuligula ferina*, of which the head and neck are bright chesnut, the breast black, the sides and scapulars marked with undulated lines of black and grayish white, is not uncommon on the coasts of Europe during the winter, and is not unfrequently seen in our markets.

Another common species is the scaup-pochard, *Fuligula marila*, which has the head and neck black glossed with green, the back and scapulars whitish with undulating black lines, and the alar speculum white.

The canvass-backed pochard just alluded to, *Fuligula valisneria* (Plate CCCCII. fig. 4), resembles the red-headed species, and is characterized by having the forehead and cheeks dull brown; the head and upper part of the neck fulvous, the lower part with a black belt; the back, scapulars, and belly white, marked with narrow black lines. These birds arrive in the United States from the arctic regions about the middle of October, and frequent the large rivers and lakes, where they feed chiefly on the roots of a grass-like plant, the *Valisneria spiralis*. Although extremely shy, vast numbers of them are killed on account of the delicacy of their flesh. Towards evening they collect into large flocks, so extensive as sometimes to cover several acres, and, when rising simultaneously on wing, to produce a noise like thunder.

The *eiders*, genus SOMATERIA, have the bill more elongated than that of the garrots, tumid and elevated at the base, and extending over the forehead in the form of two narrow processes; the lamellæ large and distant; the nostrils small, oval, and medial; the wings and tail short. The males are distinguished by their greater size and superior beauty. Only two species of this genus are known, both inhabiting the northern and temperate regions of Europe and America.

The common or St Cuthbert's eider, *Somateria mollissima*, is characterized by having the bill furnished at its base with lateral prolongations, in the form of two narrow flat lamellæ. The male has the lower parts black, the upper parts and the neck white, the top of the head violet-black, and the cheeks pale green. The female has the whole plumage reddish brown, with transverse black bars. This species is extremely abundant in Iceland, Lapland, Greenland, Spitzbergen, and the countries bordering on Hudson's and Baffin's Bays; but it is also common in all the northern parts of Europe and America. The female lays five or six pale greenish-gray eggs, and lines her nest, which is composed of sea-weeds and other maritime plants, with the fine and elastic gray down, which she plucks from her breast for that purpose. This down is carefully collected in northern countries,—each nest being generally robbed twice in the season. One female is stated to yield half a pound of down, which, however, is reduced to one half by being cleaned. It is extremely soft and warm, and so elastic that two handfuls are sufficient to fill a quilt five feet square. In 1750, the Iceland Company at Copenhagen sold so much of this article as produced 3747 rix-dollars, in addition to what was sent directly to Gluckstadt. Besides supplying this valuable down, the eiders afford an esteemed article of food to the Greenlanders, who moreover convert their skins into warm and comfortable under garments. Although the species occurs in Britain, it is nowhere so plentiful as to afford enough of down to render it available as an article of commerce.

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The king-eider, *Somateria spectabilis*, which has the lateral prolongations at the base of the bill in the form of two elevated, compressed tubercles, is very similar to the other species, and inhabits the same countries, breeding in the same manner, and lining its nest with down of equal quality, plucked from its own plumage. The skins are formed into winter garments by the inhabitants of Siberia and Kamtschatka; but as this species is not so numerous as the other, its down is not of equal importance in a commercial point of view.

Other groups of ducks have the hind toe not bordered by any membrane, the head smaller, the feet narrower, the neck longer, the bill less tapering, and the body more slender. They feed chiefly on vegetable substances, although they also devour fishes, insects, worms, and mollusca. In this section, likewise, various generic divisions have been made.

The *shovellers*, genus RHYNCHASPIS, have the bill longer than the head, with the upper mandible semi-cylindrical, and enlarged at the end, and the lamellæ so long and slender as to resemble filaments.

The common shoveller, *Rhynchaspis clypeata*, inhabits various parts of the north of Europe and America, and is sometimes met with in England. It is about twenty inches in length, with the head and neck glossy-green, the back brown, the breast and abdomen brownish red, and the smaller wing-coverts pale blue.

Another species, the fasciated shoveller, *Rhynchaspis fasciata*, of a rusty-brown colour, transversely striped with white beneath, and having the tip of the bill membranaceous, is a native of New South Wales.

The *shelducks*, genus TADORNA, have the bill tumid and elevated at the base, where there is a small tubercle, but much flattened towards the point; the lamellæ short and distant; the nostrils oval and medial.

The common shieldrake, *Tadorna Bellonii*, which is one of the most beautiful species of this family, is not very uncommon in some parts of Britain, and occurs also on the coasts of the northern and western countries of Europe. It is characterized by having the head and upper part of the neck greenish black; the back, wing-coverts, and flanks white; the scapulars black, and a broad band on the breast ferruginous. The female nestles in a rabbit-burrow, or other hole in the sandy pastures on the sea-shore, generally forming her nest of down plucked from her breast, and laying from eight to twelve white eggs. Instances have occurred of its breeding with the common duck; and Montagu states that it bears confinement well, appearing to enjoy perfect health, provided access to a pond is allowed it.

The *musk-ducks*, genus CAIRINA, have the bill also furnished with an elevated tubercle at the base; the edges of the mandibles sinuated; the face and lores covered with a bare tuberculated skin; and the wings furnished with a knob or spur at the bend.

The common musk-duck, *Cairina moschata*, which is now generally distributed over Europe in a domesticated

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state, is a native of the warmer parts of America. In its natural state it has the plumage entirely of a black colour, glossed with green and blue, excepting the wing-coverts, which are white.

The *pintails*, genus DAFILA, have the bill destitute of tubercle at the base, narrow, somewhat cylindrical, with its edges dentato-laminate; the nostrils are basal, and the tail elongated, and tapering to a point.

The common pintail, *Dafila acuta*, has the head umber-brown, with a longitudinal white line on each side of the occiput and hind neck; the back and flanks undulated with black and grayish white; the lower parts white; and the two central tail-feathers black. It breeds in the arctic regions of Europe, Asia, and America; retires southward in winter; is very shy and vigilant; and is much esteemed as an article of food.

The ducks, strictly so called, genus ANAS, are distinguished by having the bill simple at the base, as long as the head, depressed, broad, and obtuse; the nostrils oval and small; the tail moderate, even, or rounded, often with the middle feathers and their coverts recurved.

Of this genus, the most common species in Europe is that which is supposed to be the original of the domestic duck, and which with us is named the wild duck or mallard, *Anas boschas*. The male is a very beautiful bird, having the head and upper part of the neck deep green, the latter with a white ring; the four middle tail-feathers recurved; the upper parts marked with fine undulated grayish-brown and white lines, the breast deep chesnut, the lower parts grayish white, undulated with grayish-brown lines; the alar spot green, edged above and below with white. It inhabits all the northern countries of the globe, and is common in Britain, where it breeds, forming its nest of withered plants in marshy places, and laying from ten to fifteen bluish-white eggs. Instances have occurred of its occupying the deserted nest of a crow. Its flesh is justly held in great estimation, and vast numbers are shot and caught in decoys. The following account of the method employed in capturing wild ducks in the fens of Lincolnshire is given by Bewick.

"In the lakes where they resort, the most favourite haunts of the fowl are observed: then in the most sequestered part of this haunt they cut a ditch about four yards across at the entrance, and about fifty or sixty yards in length, decreasing gradually in width from the entrance to the farther end, which is not more than two feet wide. It is of a semicircular form, but not bending much for the first ten yards. The banks of the lake, for about ten yards on each side of this ditch (or pipe, as it is called), are kept clear from reeds, coarse herbage, &c. in order that the fowl may get on them to sit and dress themselves. Across this ditch, poles on each side, close to the edge of the ditch, are driven into the ground, and the tops bent to each other, and tied fast. These poles at the entrance form an arch, from the top of which to the water is about ten feet. This arch is made to decrease in height as the ditch decreases in width, till the farther end is not more than eighteen inches in height. The poles are placed about six feet from each other, and connected together by poles laid lengthwise across the arch, and tied together. Over them a net with meshes sufficiently small to prevent the fowl getting through is thrown across, and made fast to a reed fence at the entrance, and nine or ten yards up the ditch, and afterwards strongly pegged to the ground. At the farther end of the pipe a tunnel-net, as it is called, is fixed, about four yards in length, of a round form, and kept open by a number of hoops about eighteen inches in diameter, placed at a small distance from each other to keep it distended. Supposing the circular bend of the pipe to be to the right, when you stand with your back to the lake, on the left-hand side, a number of reed-fences are constructed, called shootings, for the purpose of screening from sight the *decoy-man*, and in such a manner that the fowl in the decoy may not be alarmed when he is driving those in the pipe: these shootings are about four yards in length, and about six feet high, and are ten in number. From the end of the last shooting a person cannot see the lake, owing to the bend in the pipes: there is then no farther occasion for shelter. Were it not for these shootings, the fowl that remain about the mouth of the pipe would be alarmed, if the person driving the fowl already under the net should be exposed, and would become so shy as to forsake the place entirely. The first thing the decoy-man does when he approaches the pipe, is to take a piece of lighted turf or peat, and hold it near his mouth, to prevent the fowl smelling him. He is attended by a dog taught for the purpose of assisting him; he walks very silently about half-way up the shootings, where a small piece of wood is thrust through the reed fence, which makes an aperture just sufficient to see if any fowl are in; if not, he walks forward to see if any are about the mouth of the pipe. If there are, he stops and makes a motion to his dog, and gives him a piece of cheese or something to eat; upon receiving it, he goes directly to a hole in the reed-fence, and the fowl immediately fly off the bank into the water; the dog returns along the bank between the reed-fences and the pipe, and comes out to his master at another hole. The man now gives him another reward, and he repeats his round again, till the fowl are attracted by the motion of the dog, and follow him into the mouth of the pipe. This operation is called working them. The man now retreats farther back, working the dog at different holes till the fowl are directly under the net; he now commands his dog to lie down still behind the fence, and goes forward to the end of the pipe next the lake, where he takes off his hat, and gives it a wave between the shooting; all the fowl under the net can see him, but none that are in the lake can. The fowl that are in sight fly forward, and the man runs forward to the next shooting and waves his hat, and so on, driving them along till they come to the tunnel-net, where they creep in: when they are all in he gives the net a twist, so as to prevent their getting back; he then takes the net off from the end of the pipe with what fowl he may have caught, and takes them out one at a time, and dislocates their necks, and hangs the net on again, and all is ready for working again. In this manner five or six dozen have been taken at one drift. When the wind blows directly in or out of the pipes, the fowl seldom work well, especially when it blows in. If many pipes are made in the lake, they are so constructed as to suit different winds."[1] The better to entice the fowl into the pipe, hempseed is strewed occasionally in the water. The season allowed by act of parliament for catching these birds in this way is from the latter end of October till February.

The Chinese duck, *Anas galericulata*, with a pendent crest, and the inner wing-feathers enlarged and raised in a vertical direction, is an extremely beautiful species, a native of China and Japan.

The summer duck, *Anas sponsa*, which also has a pendent crest, is not less beautiful. (Plate CCCCII. fig. 8.) It inhabits Mexico and other parts of North America, migrating northward in summer, rarely visiting the seashore or salt marshes, but frequenting the muddy creeks, ponds, and mill-dams of the interior.

The tree duck, *Anas arborea*, of a gray colour, the ab-

[1] *British Birds*, vol. ii. p. 294.

Illiger's System.

domen spotted with black and white, and the head slightly crested, inhabits the warmer parts of America, and is remarkable for building in the holes of decayed trees.

The gadwall or gray, *Anas strepera*, the Dominican duck, *A. Dominicana*, the Spanish duck, *A. viduata*, and many other species, belong to this genus,—which might include the teals, although these are separated by several authors.

The wigeons, genus Mareca, may be distinguished from the ducks, as they have the bill shorter than the head, higher than broad at the base, depressed and narrowed towards the end; the lamellæ slightly projecting; the tail short and acute. They are, however, very intimately allied to the pintails.

Of this genus one of the best examples is the common wigeon, *Mareca Penelope*, which has the forehead yellowish white, the rest of the head and the neck chesnut-red, the back and flanks undulated with black and white. The male of this species has been known to pair with the female pintail, and produce a hybrid brood. It also pairs with the common duck. Wigeons are abundant in winter in many parts of Britain, and are very much esteemed for the table.

The teals, genus Querquedula, are distinguished from the other groups by their diminutive size. Their bill is narrower than that of the wigeons, proportionally longer, and has its base more elevated. The species are generally very beautiful.

The garganey teal, *Querquedula circia*, of a gray colour, variegated with black, and having a white streak above the eyes, with a green spot on the wing, inhabits the more temperate parts of Europe, and is abundant in Holland during its winter migration.

The common teal, *Querquedula crecca*, which has the head brownish red, the body transversely undulated with dusky, a white line above and another beneath the eye, and the alar spot black and green, is plentiful in many parts of Europe and North America; while the blue-winged teal, *Q. discors*, characterized by the light blue colour of the wing-coverts, is peculiar to the latter continent, as is likewise the American teal, *Q. Carolinensis*.

Illiger's System.

The second principal group named *Mergidæ*, consisting of the genus Mergus of Linnæus, includes the remaining birds of the great family of Lamellirostres, which are usually designated by the vernacular name of *merganser*. They differ from the ducks in having their bill slender, almost cylindrical, and furnished on the margins with dentiform points directed backwards, and resembling the teeth of a saw. (Plate CCCCII. fig. 6.) Their summer residence is in the colder regions of both continents, whence they migrate southward on the approach of winter. Their body is elongated and depressed, their feet short and placed far behind, their wings rather long and narrow, their neck of moderate length. They fly with rapidity, swim and dive with the greatest facility, and generally feed on fishes. In their habits they are intermediate between the ducks and divers; but in their organization and plumage they are more nearly allied to the former. Their tracheæ, besides having an exceedingly large dilatation at its bifurcation, is also enlarged previous to its entrance into the thorax. In accordance with their piscivorous propensities, their gullet is wider than that of the ducks, and their gizzard less muscular.

Three species occur in the temperate parts of Europe. The goosander, *Mergus merganser*, of which the male is black, with the lower parts buff-coloured, and the head purplish green, with a slender elongated crest; the red-breasted merganser, *M. serrator*, about the size of the mallard, also crested, the male black above, white beneath, with the head dark green; and the smew, *M. albellus*, which is smaller than the golden-eye, varied with black and white, and having a large compressed white crest. All these occur also in the northern parts of America, which has moreover a species peculiar to itself, the hooded merganser, *M. cucullatus* (Plate CCCCII. fig. 7), of a blackish colour above, white beneath, with a semicircular black crest, white on each side. The females and young of all the species differ greatly in colour from the adult males. (T.)

THE ORDERS, FAMILIES, AND GENERA, OF BIRDS, ACCORDING TO THE SYSTEM OF ILLIGER.[1]

Order I.—Scansores.

Family *Psittacini*.....	Gen. Psittacus, Pezoporus (πεζοπορος, pedester).
Family *Serrati*.....	Gen. Rhamphastos, Pteroglossus (πτερον, *penna*, γλοσσα, *lingua*), Pogonias (πωγωνιας, *barbatus*), Corythaix (κορυθαιξ, *galea, cristam movens*), Trogon, Musophaga.
Family *Amphiboli*.....	Gen. Crotophaga, Scythrops, Bucco, Cuculus, Centropus (κεντριν, *stimulus, calcar*; πους, *pes*).
Family *Sagittilingues*.....	Gen. Yunx, Picus.
Family *Syndactyli*.....	Gen. Galbula.

Order II.—Ambulatores.

Family *Angulirostres*.....	Gen. Alcedo, Merops.
Family *Suspensi*.....	Gen. Trochilus.
Family *Tenuirostres*.....	Gen. Nectarinia (*nectar florum haurientes*), Tichodroma (τειχος, *murus*, δρομος, *cursitans*), Upupa.

[1] *Prodromus Mammalium et Avium*, Berlin, 1811.

Illiger's System.

Family *Pygarrhichi*..... Gen. Certhia, Dendrocolaptes.
Family *Gregarii*..... Gen. Xenops (ξενος, *inusitatus, novus*, ωψ, *vultus*), Sitta, Buphaga, Oriolus, Cassicus, Sturnus.
Family *Canori*..... Gen. Turdus, Cinclus, Accentor, Motacilla, Muscicapa, Myiothera (μυια, *musca*, θηραω, *venor, capto*), Lanius, Sparactes (σπαραχτης, *lanio, lacerator*), Todus, Pipra.
Family *Passerini*..... Gen. Parus, Alauda, Emberiza, Tanagra, Fringilla, Loxia, Colius, Glaucopis, Phytotoma.
Family *Dentirostres*..... Gen. Prionites (πριων, *serra*), Buceros.
Family *Coraces*..... Gen. Corvus, Coracias, Paradisea, Cephalopterus, Gracula.
Family *Sericati*..... Gen. Ampelis, Procnias.
Family *Hiantes*..... Gen. Hirundo, Cypselus, Caprimulgus.

Illiger's System.

Order III.—Raptores.

Family *Nocturni*..... Gen. Strix.
Family *Accipitrini*..... Gen. Falco, Gypogeranus (γυψ, *vultur*, γερανος, *grus*), Gypaëtus.
Family *Vulturini*..... Gen. Vultur, Cathartes (καθαρτης, *purgator*).

Order IV.—Rasores.

Family *Gallinacei*..... Gen. Numida, Meleagris, Penelope, Crax, Opisthocomus (Hoffmansegg, οπισθοκομος, *occipite comatus*), Pavo, Phasianus, Gallus, Menura, Tetrao, Perdix.
Family *Epollicati*..... Gen. Ortygis (ορτυξ, *coturnix*), Syrrhaptes (συῤῥαπτειν, *consuere*).
Family *Columbini*..... Gen. Columba.
Family *Crypturi*..... Gen. Crypturus (κρυπτειν, *occultare*, ουρη, *cauda*).
Family *Inepti*..... Gen. Didus.

Order V.—Cursores.

Family *Proceri*..... Gen. Casuarius, Struthio, Rhea.
Family *Campestres*..... Gen. Otis.
Family *Littorales*..... Gen. Charadrius, Calidris, Himantopus, Hæmatopus, Tachydromus (ταχυδρομος, *velociter currens*), Burhinus.

Order VI.—Grallatores.

Family *Vaginati*..... Gen. Chionis.
Family *Alectorides*..... Gen. Glareola, Cereopsis, Dicholophus (δις, *bifariam*; λοφος, *crista*), Palamedea, Chauna (χαυνος, *fungosus, inflatus, inanis*), Psophia.
Family *Herodii*..... Gen. Grus, Ciconia, Ardea, Eurypyga (ευρυς, *latus*, πυγη, *anus, cauda*), Scopus, Cancroma, Anastomus.
Family *Falcati*..... Gen. Tantalus, Ibis.
Family *Limicolæ*..... Gen. Numenius, Scolopax, Ereunetes (ερευνητης, *explorator*), Actitis (ακτιτις, *in littore degens*), Strepsilas (στρεψειν, *vertere*, λας, *lapis*), Tringa.
Family *Macrodactyli*..... Gen. Parra, Rallus, Crex.
Family *Lobipedes*..... Gen. Fulica, Podoa (πους, *pes*, ωα, *limbus, fimbria*), Phalaropus.
Family *Hygrobatæ*..... Gen. Corrira, Recurvirostra, Platalea, Phænicopterus.

Order VII.—Natatores.

Family *Longipennes*..... Gen. Rhyncops, Sterna, Larus, Lestris (ληστρις, *prædatrix*).
Family *Tubinares*..... Gen. Procellaria, Haladroma (αλαδρομας, *in mare cursitans*), Pachyptila (παχυς, *densus*, πτιλον, *pluma*), Diomedea.
Family *Lamelloso-dentati*... Gen. Anas, Anser, Mergus.
Family *Steganopodes*..... Gen. Pelecanus, Halieus (αλευς, *piscator*), Dysporus, Phaëton, Plotus.
Family *Pygodopes*..... Gen. Colymbus, Eudytes (ευ, *bene, facile*, δυτης, *urinator*), Uria, Mormon (μορμον, *larva*), Alca.
Family *Impennes*..... Gen. Aptenodytes.

Temminck's and Vigors's Systems.

THE ORNITHOLOGICAL SYSTEM OF M. TEMMINCK.[1]

Order I.—Rapaces.

Genera.—Vultur, Cathartes, Gypætus, Gypogeranus, Falco, Strix.

Order II.—Omnivores.

Genera.—Opisthocomus, Buceros, Prionites, Corvus, Nucifraga, Pyrrhocorax, Barita, Glaucopis, Gracula, Buphaga, Bombycivora, Ptilonorhynchus, Coracias, Colaris, Oriolus, Icterus, Sturnus, Pastor, Paradisea, Lamprotornis.

Order III.—Insectivores.

Genera.—Turdus, Cinclus, Menura, Pitta, Myothera, Tamnophilus, Vanga, Lanius, Psaris, Sparactes, Ocypterus, Criniger, Edolius, Ceblepyris, Coracina, Ampelis, Casmarhinchos, Procnias, Rupicola, Phibalura, Pipra, Pardalotus, Todus, Platyrhinchos, Muscipeta, Muscicapa, Malurus, Sylvia, Saxicola, Accentor, Motacilla, Anthus.

Order IV.—Granivores.

Genera.—Alauda, Parus, Emberiza, Tanagra, Ploceus, Loxia, Psittirostra, Pyrrhula, Fringilla, Phytotoma, Colius.

Order V.—Zygodactyli.

First Family.

Genera.—Musophaga, Indicator, Cuculus, Coccyzus, Centropus, Phœnicophaus, Leptosomus, Scythrops, Pteroglossus, Ramphastos, Crotophaga, Trogon, Capito, Bucco, Pogonias, Psittacus.

Second Family.

Genera.—Picus, Yunx.

Order VI.—Anisodactyli.

Genera.—Oxyrincus, Orthonyx, Dendrocolaptes, Xenops, Anabates, Opetiorynchos, Certhia, Cereba, Trochilus, Nectarinia, Climacteris, Tichodroma, Upupa, Epimachus, Drepanis, Meliphaga.

Order VII.—Alciones.

Genera.—Merops, Alcedo, Dacelo.

Order VIII.—Chelidones.

Genera.—Hirundo, Cypselus, Caprimulgus.

Order IX.—Columbæ.

Genus.—Columba.

Order X.—Gallinæ.

Genera.—Pavo, Gallus, Phasianus, Lophophorus, Polyplectron, Meleagris, Argus, Numida, Pauxi, Crax, Penelope, Tetrao, Pterocles, Syrrhaptes, Perdix, Cryptonyx, Tinamus, Hemipodius.

Order XI.—Alectorides.

Genera.—Psophia, Dicholophus, Glareola, Palamedea, Chauna.

Order XII.—Cursores.

Genera.—Struthio, Rhea, Casuarius, Otis, Cursorius.

Order XIII.—Grallatores.

First Family.

Genera.—Œdicnemus, Calidris, Falcinellus, Himantopus, Hæmatopus, Charadrius.

Second Family.

Genera.—Vanellus, Strepsilus, Grus, Aramus, Ardea, Ciconia, Anastomus, Scopus, Phœnicopterus, Recurvirostra, Cancroma, Platalea, Tantalus, Ibis, Numenius, Tringa, Totanus, Limosa, Scolopax, Rynchæa, Eurypyga, Rallus, Gallinula, Parra, Porphyrio.

Order XIV.—Pinnatipedes.

Genera.—Fulica, Podoa, Phalaropus, Podiceps.

Order XV.—Palmipedes.

Genera.—Cereopsis, Chionis, Rynchops, Sterna, Larus, Lestris, Procellaria, Pachyptila, Haladroma, Diomedea, Anas, Mergus, Pelecanus, Carbo, Tachypetes, Sula, Plotus, Phaëton, Uria, Phaleris, Mormon, Alca, Sphenicus, Aptenodytes.

Order XVI.—Inertes.

Genera.—Apteryx, Didus.

THE CLASSIFICATION OF BIRDS, AS PROPOSED BY MR VIGORS.[2]

Order I.—Raptores, Ill. (Accipitres, Linn.)

1st Family. —— ?—Gen. Gypogeranus, Ill. (Serpentarius, Cuv.; Ophiotheres, Vieill.).

2d Family. Vulturidæ.—1. —— Gen. Cathartes, Ill. (Catharista, Vieill.); 2. —— Gen. Sarcoramphus, Dum. (Cathartis pars, Ill.; Gypagus, Vieill.); 3. —— Gen. Gyps, Sav.; Vultur, Auct. (Ægypius, Sav.); 4. —— Gen. Gypætus, Storr. (Phene, Sav.); 5. —— Gen. Neophron, Sav. (Cathartis pars, Temm.).

3d Family. Falconidæ, Leach.—1. Sub-fam. *Aquilina.* Gen. Ibycter, Vieill.; Daptrius, Vieill.; Polyborus, Vieill.; Pandion, Sav.; Haliæetus, Sav.; Aquila, Auct.; Harpyia, Cuv.; Physeta, Vieill.; Morphnus, Cuv. (Spizaëtus, Vieill.); Cymindis, Cuv.; Asturina, Vieill. 2. Sub-fam. *Accipitrina.* Gen. Dædalion, Sav.; Astur, Auct. (Sparvius, Vieill.); Accipiter, Auct.; Harpagus; Gampsonyx. 3. Sub-fam. *Falconina.* Gen. Hierax, Vig.; Falco, Auct. 4. Sub-fam. *Buteonina.* Gen. Ictinia, Vieill.; Circus, Auct.; Pernis, Cuv.; Buteo, Auct. 5. Sub-fam. *Milvina.* Gen. Elanus, Sav.; Nauclerus, Vig.; Milvus, Auct.

4th Family. Strigidæ, Leach.—1. Sub-fam. *Noctuina.* Gen. Surnia, Dum.; Noctua, Sav. 2. Sub-fam. *Bubonina.* Gen. Scops, Sav.; Bubo, Cuv. 3. Sub-fam. *Asionina.* Gen. Asio, Antiq. (Olus, Cuv.). 4. Sub-fam. *Strigina.* Gen. Ulula, Cuv.; Strix, Auct. 5. Sub-fam. *Syrniana.* Gen. Syrnium, Linn.

5th Family. ——?

[1] From the *Manuel d'Ornithologie*, i. xlviii. 1820.

[2] In the *Zoological Journal*, No. vii. p. 392. 1825.

Vigors's System.

ORDER II.—INSESSORES. (Picæ, Passeres, Linn.)

Tribe I.—Fissirostres, Cuv.

1ST FAMILY. MEROPIDÆ.—Gen. Merops, Linn. (Apiaster, Briss.).

2D FAMILY. HIRUNDINIDÆ.—Gen. Cypselus, Ill. (Apus, Cuv.; Micropus, Meyer); Hirundo, Auct.

3D FAMILY. CAPRIMULGIDÆ.—Gen. Caprimulgus, Auct.; Podargus, Cuv.; Ægotheles, Vig. and Hors.; Steatornis, Humb.; Nyctebius, Vieill.

4TH FAMILY. TODIDÆ.—Gen. Eurylaimus, Horsf.; Eurystomus, Vieill. (Colaris, Cuv.); Todus, Auct.

5TH FAMILY. HALCYONIDÆ.—Gen. Alcedo, Linn. (Ispida, Briss.); Halcyon, Swains.; Dacelo, Leach; Tanysiptera, Vig.; Galbula, Briss.; Capito, Vieill.? Monasa, Vieill.?

Tribe II.—Dentirostres, Cuv.

1ST FAMILY. MUSCICAPIDÆ.—Gen. Platyrhynchus, Desm.; Muscicapa, Auct.; Muscipeta, Cuv.; Onychorhynchus, Fisch.; Vireo, Vieill.? Icteria, Vieill.?

2D FAMILY. LANIADÆ.—1. Sub-fam. *Tyrannina*, Swains. Gen. Tyrannus, Cuv.; Tityra, Vieill. (Psaris, Cuv.); Gubernetes, Such. 2. Sub-fam. *Dicrurina*, Swains. Gen. Artamus, Vieill. (Ocypterus, Cuv.); Dicrurus, Vieill. (Edolius, Cuv.); Trichophorus, Temm.? Irena, Horsf. 3. Sub-fam. *Laniana*, Swains. Gen. Sparactes, Ill.; Lanius, Auct.; Falcunculus, Vieill.; Cyclarhis, Swains.; Lanio, Vieill.? 4. Sub-fam. *Thamnophilina*, Swains. Gen. Vanga, Cuv.; Thamnophilus, Vieill.; Malaconotus, Swains.; Formicivora, Swains.; Drymophila, Swains.; Laniarius, Vieill.; Prionops, Vieill. 5. Sub-fam. *Campephagina*, Swains. Gen. Grauculus, Cuv.; Campephaga, Vieill. (Ceblepyris, Cuv.).

3D FAMILY. MERULIDÆ.—1. Sub-fam. *Myotherina*, Swains. Gen. Urotomus, Swains.; Myothera, Ill. (Myrmothera, Vieill.); Pitta, Vieill.; Grallaria, Vieill.; Conophaga, Vieill.; Cinclus, Bechst.? (Hydrobata, Vieill.); Chamæza, Vig. 2. Sub-fam. *Merulina*. Gen. Merula, Ray; Sphecotheres, Vieill.? 3. Sub-fam. *Oriolina*. Gen. Oriolus, Auct. 4. Sub-fam. *Cossyphina*. Gen. Cossypha, Vig.; Timalia, Horsf.? 5. Gen. Petrocincla, Vig.

4TH FAMILY. SYLVIADÆ.—1. ——? Gen. Hylophilus, Temm.; Iora, Horsf.; Accentor, Bechst.; Prunella, Gessn.? 2. ——? Gen. Brachypteryx, Horsf.; Curruca, Bechst.; Ficedula, Bechst.; Œgithina, Vieill.? 3. Sub-fam. *Sylviana*. Gen. Sylvia, Auct.; Melizophilus, Leach; Synallaxis, Vieill.; Malurus, Vieill.; Troglodytes, Cuv.; Regulus, Cuv.; Tyrannulus, Vieill. 4. Sub-fam. *Motacillina*. Gen. Motacilla, Auct.; Budytes, Cuv.; Enicurus, Temm.; Anthus, Bechst.; Corydalla, Vig.; Megalurus, Horsf. 5. Sub-fam. *Saxicolina*. Gen. Saxicola, Bechst. (Œnanthe, Vieill.).

5TH FAMILY. PIPRIDÆ.—Gen. Ægithalus, Vig.; Parus, Linn.; Megistina, Vieill.; Pardalotus, Vieill.; Pipra, Linn. (Manacus, Briss.); Rupicola, Briss.; Calyptomena, Raffles; Phibalura, Vieill.; Bombicilla, Briss.; Ampelis, Auct. (Cotinga, Briss.; Tersa, Vieill.); Procnias, Hoffm.; Casmarhynchus, Temm. (Ampelis, Vieill.); Querula, Vieill.; Coracina, Vieill. (Cephalopterus, Geoff.); Pachycephala, Swains.

Tribe III.—Conirostres, Cuv.

1ST FAMILY. FRINGILLIDÆ.—1. Sub-fam. *Tanagrina?* Gen. Euphonia, Vieill.; Nemosia, Vieill.; Tachyphonus, Vieill.; Saltator, Vieill.; Tanagra, Auct.; Pyranga, Vieill.; Ramphopis, Vieill.; Arremon, Vieill.; Dulus, Vieill.? Pipilo, Vieill. 2. Sub-fam. *Alaudina*. Gen. Emberiza, Linn.; Passerina, Vieill.; Alauda, Auct.; Mirafra, Horsf. 3. Sub-fam. *Carduelina*. Gen. Carduelis, Briss.; Ploceus, Cuv. (Agelaii pars, Vieill.). 4. Sub-fam. *Passerina*. Gen. Fringilla, Auct.; Passer, Auct. (Pyrgita, Cuv.). 5. Sub-fam. *Pyrrhulina?* Gen. Linaria, Bechst.; Vidua, Cuv.; Pyrrhula, Briss.?

Vigors's System.

2D FAMILY. STURNIDÆ.—1. Sub-fam. *Icterina*. Gen. Xanthornus, Cuv. (Yphantes, Vieill.); Icterus, Cuv. (Pendulinus, Vieill.); Sycobius, Vieill.? Quiscalus, Vieill.; Cassicus, Daud.; Leïstes (Agelaii pars, Vieill.). 2. Sub-fam. *Sturnina*. Gen. Sturnella, Vieill.; Sturnus, Linn.; Amblyramphus, Leach; Dilophus, Vieill.? 3. ——? Gen. Lamprotornis, Temm.; Acridotheres, Vieill. (Gracula, Cuv.). 4. ——? Gen. Pastor, Temm. (Psaroidos, Vieill.); Grallina, Vieill.? 5. ——? Gen. Buphaga, Linn.

3D FAMILY. CORVIDÆ, Leach.—1. ——? Gen. Cracticus, Vieill. (Barita, Cuv.); Nucifraga, Briss. 2. Sub-fam. *Corvina*. Gen. Pica, Briss.; Garrulus, Briss.; Corvus, Auct. 3. Sub-fam. *Coraciana*. Gen. Coracias, Linn. (Galgulus, Briss.); Gracula, Auct. (Eulabes, Cuv.); Ptilonorhynchus, Kuhl; Glaucopis, Forst. (Callæas, Lath.); Crypsirina, Vieill. (Phrenotrix, Horsf.). 4. Sub-fam. *Paradiseana*. Astrapia, Vieill.; Parotia, Vieill.; Paradisea, Linn. (Manucodiata, Briss.); Lophorina, Vieill.; Cicinnurus, Vieill.; Epimachus, Cuv.? 5. ——? Gen. Fregilus, Cuv. (Coracias, Briss.); Pyrrhocorax, Vieill.

4TH FAMILY. BUCERIDÆ, Leach.—Gen. Buceros, Linn. (Hydrocorax, Briss.); Momotus, Briss. (Prionites, Ill.; Baryphonus, Vieill.).

5TH FAMILY. LOXIADÆ.—Gen. Phytotoma, Gmel.; Coccothraustes, Briss.; Pytilus, Cuv.; Loxia, Briss.; Psittirostra, Temm.; Colius, Linn.? Cissopis, Vieill. (Bethylus, Cuv.); Strobilophaga, Vieill. (Corythus, Cuv.).

Tribe IV.—Scansores, Auct.

1ST FAMILY. RAMPHASTIDÆ.—Gen. Scythrops, Lath.; Ramphastos, Linn. (Tucana, Briss.); Pteroglossus, Ill.

2D FAMILY. PSITTACIDÆ, Leach.—1. Sub-fam. *Psittacina*. Gen. Psittacus, Auct.; Androglossa. 2. Sub-fam. *Plyctolophina*. Gen. Plyctolophus, Vieill.; Calyptorhynchus, Vig. and Hors.; Microglossum, Geoff. 3. Sub-fam. *Macrocercina*. Gen. Macrocercus, Vieill. 4. Sub-fam. *Palæornina*. Gen. Psittacara; Nanodes, Vig. and Hors.; Platycercus; Pezoporus, Ill.; Palæornis, Vig.; Trichoglossus, Vig. and Hors.; Lorius, Vig.; Brotogeris, Vig. 5. Sub-fam. *Psittaculina*. Gen. Psittacula, Kuhl.

3D FAMILY. PICIDÆ.—Gen. Pogonias, Ill.; Bucco, Auct.; Picus, Linn.; Colaptes, Swains.; Yunx, Linn. (Torquilla, Briss.).

4TH FAMILY. CERTHIADÆ.—Gen. Dendrocolaptes, Herm. (Dendrocopus, Vieill.); Certhia, Auct.; Climacteris, Temm.; Orthonyx, Temm.; Tichodroma, Ill. (Petrodroma, Vieill.); Upupa, Linn.; Sitta, Linn.; Xenops, Hoffm.; Orthotomus, Horsf.; Neops, Vieill.; Mniotilta, Vieill.; Thriothurus, Vieill.; Pyrrota, Vieill.? Opetiorhynchus, Temm.; Oxyrhynchus, Temm.

5TH FAMILY. CUCULIDÆ, Leach.—Gen. Coccyzus, Vieill.; Leptosomus, Vieill.; Cuculus, Auct.; Indicator, Vieill.; Centropus, Ill. (Corydonyx, Vieill.); Saurothera, Vieill.; Phænicophaus, Vieill.; Crotophaga, Linn.; Trogon, Linn.; Corythaix, Ill.? (Opæthus, Vieill.); Musophaga, Isert.?

Tribe V.—Tenuirostres, Cuv.

1ST FAMILY. NECTARINIADÆ?—Gen. Nectarinia, Ill.; (Cæreba, Vieill.); Dacnis, Cuv.; Furnarius, Vieill.?

2D FAMILY. CYNNYRIDÆ.—Gen. Cinnyris, Cuv. (Mellisuga, Vieill.); Dicæum, Cuv.; Drepanis, Temm.

3D FAMILY. TROCHILIDÆ.—Gen. Trochilus, Auct. (Polytmus, Briss.); Mellisuga, Briss. (Orthorhynchus, Lacepede).

4TH FAMILY. PROMEROPIDÆ.—Gen. Promerops, Briss. (Falcinellus, Vieill.).

5TH FAMILY. MELIPHAGIDÆ.—Gen. Meliphaga, Lewin

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(Philedon, Cuv.; Philemon, Vieill.); Melithreptus, Vieill.; Creadion, Vieill.; Mimetes, King? Sericulus, Swains.? Ptiloris, Swains.; Pomatorhinus, Horsf.? Prinia, Horsf.?

ORDER III.—RASORES, Ill. (Gallinæ, Linn.)

1ST FAMILY. COLUMBIDÆ, Leach.—Gen. Treron, Vieill. (Vinago, Cuv.); Columba, Auct.; Ptilinopus, Swains.; Lophyrus, Vieill.

2D FAMILY. PHASIANIDÆ.—Gen. Meleagris, Linn. (Gallopavo, Briss.); Pavo, Linn.; Diplectron, Vieill. (Polyplectron, Temm.); Gallus, Briss.; Monaulus, Vieill. (Lophophorus, Temm.); Phasianus, Auct.; Argus, Temm.; Numida, Linn. (Melegris, Briss.).

3D FAMILY. TETRAONIDÆ, Leach.—Gen. Liponyx, Vieill. (Cryptonyx, Temm.); Odontophorus, Vieill.; Coturnix, Cuv.; Perdix, Briss.; Ganga, Vieill. (Pterocles, Temm.); Tetrao, Auct.; Lagopus, Vieill.; Syrrhaptes, Ill. (Heteroclitus, Vieill.); Ortygis, Ill. (Ortygodes, Vieill.; Hemipodius, Temm.); Tinamus, Lath. (Crypturus, Ill.; Cryptura, Vieill.).

4TH FAMILY. STRUTHIONIDÆ.—Gen. Rhea, Briss.; Struthio, Linn.; Casuarius, Briss.; Dromiceius, Vieill.; Didus, Linn. (Raphus, Briss.); Otis, Linn.

5TH FAMILY. CRACIDÆ.—Gen. Ourax, Cuv. (Pauxi, Temm.); Crax, Linn.; Penelope, Merr.; Ortalida, Merr.; Opisthocomus, Hoffm.? (Orthocorys, Vieill.); Menura, Lath.; Megapodius, Temm.

ORDER IV.—GRALLATORES, Ill. (Grallæ, Linn.)

1ST FAMILY. GRUIDÆ.—Gen. Psophia, Linn.; Anthropoïdes, Vieill.; Balearica, Briss.; Grus, Pall.; Cariama, Briss. (Dicholophus, Ill.; Zophorhynchus, Vieill.; Macrodactylus, Geoff.).

2D FAMILY. ARDEIDÆ, Leach.—Gen. Aramus, Vieill.; Eurypyga, Ill. (Helias, Vieill.); Ardea, Auct.; Canchroma, Linn. (Cochlearius, Briss.); Phænicopterus, Linn.; Platalea, Linn. (Platea, Briss.); Ciconia, Briss.; Mycteria, Linn.; Scopus, Briss.; Anastomus, Ill. (Hians, Lacep.); Tantalus, Linn.; Ibis, Lacep. (Falcinellus, Bechst.).

3D FAMILY. SCOLOPACIDÆ.—Gen. Numenius, Briss.; Totanus, Bechst. (Actitis pars., Ill.); Recurvirostra, Linn. (Avocetta, Briss.); Limosa, Briss. (Actitis pars., Ill.; Limicula, Vieill.); Ereunetes, Ill.; Macroramphus, Leach? Scolopax, Auct.; Rusticola, Vieill.; Rynchæa, Cuv. (Rostratula, Vieill.); Machetes, Cuv. (Actitis pars., Ill.); Pelida, Cuv.; Phalaropus, Briss. (Crymophilus, Vieill.); Lobipes, Cuv. (Phalaropus, Vieill.); Tringa, Auct. (Actitis pars., Ill.); Phæopus, Cuv.

4TH FAMILY. RALLIDÆ, Leach.—Gen. Parra, Linn. (Jacana, Briss.); Palamedea, Linn. (Anhima, Briss.); Chauna, Ill. (Opistolophus, Vieill.); Glareola, Briss.; Rallus, Auct.; Chionis, Forst.? (Vaginalis, Gmel.); Crex, Bechst. (Ortygometra, Steph.); Gallinula, Briss.; Porphyrio, Briss.; Podoa, Ill. (Heliornis, Vieill.); Fulica, Auct.

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5TH FAMILY. CHARADRIADÆ, Leach.—Gen. Hæmatopus, Linn. (Ostralega, Briss.); Calidris, Ill. (Arenaria, Briss.); Falcinellus, Cuv.: Erolia, Vieill.? Cursorius, Lath. (Tachydromus, Ill.); Strepsilas, Ill.; Squatarola, Cuv.; Vanellus, Briss. (Tringa, Ill.); Pluvianus, Vieill.; Charadrius, Auct. (Pluvialis, Briss.); Burhinus, Ill.? Himantopus, Briss. (Macrotarsus, Lacep.); Œdicnemus, Cuv.

ORDER V.—NATATORES, Ill. (Anseres, Linn.)

1ST FAMILY.—ANATIDÆ, Leach.—1. Sub-fam. *Anserina.* Gen. Anser, Briss.; Bernicla, Steph.; Cheniscus, Brookes's MS.; Chenalopex, Steph.; Plectropterus, Leach. 2. Sub-fam. *Cereopsina.* Gen. Cereopsis, Lath. 3. Sub-fam. *Anatina.* Gen. Tadorna, Leach; Cairina, Flem.; Anas, Auct.; Dafila, Leach; Mareca, Steph.; Querquedula, Ray; Rhynchaspis, Leach. 4. Sub-fam. ——? Gen. Clangula, Flem.; Harelda, Ray; Fuligula, Ray; Mergus, Linn. (Merganser, Briss.); Somateria, Leach; Oidemia, Flem.; Biziura, Leach. 4. Sub-fam. *Cygnina.* Gen. Cygnus, Meyer.

2D FAMILY. COLYMBIDÆ, Leach.—Gen. Podiceps, Lath. (Colymbus, Briss. Ill.); Colymbus, Auct. (Mergus, Briss.; Eudytes, Ill.).

3D FAMILY. ALCADÆ.—Gen. Uria, Briss.; Cephus, Cuv.? Mergulus, Ray; Phaleris, Temm. (Alca, Vieill.); Fratercula, Briss. (Mormon, Ill.; Larvæ pars, Vieill.); Alca, Auct. (Larvæ pars, Vieill.); Spheniscus, Briss.; Catarractes, Briss. (Eudytes, Vieill.); Aptenodytes, Forst.

4TH FAMILY. PELECANIDÆ, Leach.—Gen. Onocrotalus, Briss.; Phalacrocorax, Briss. (Carbo, Meyer; Halieus, Ill.; Hydrocorax, Vieill.); Sula, Briss. (Dysporus, Ill.; Morus, Vieill.); Tachypetes, Vieill.; Phaëton, Linn. (Lepturus, Briss.); Plotus, Linn. (Anhinga, Briss.).

5TH FAMILY. LARIDÆ, Leach.—Gen. Sterna, Linn.; Rhynchops, Linn. (Rygchopsalia, Briss.); Larus, Auct.; Stercorarius, Briss. (Lestris, Ill.; Prædatrix, Vieill.); Diomedea, Linn. (Albatrus, Briss.); Haladroma, Ill.; Procellaria, Auct.; Pachyptila, Ill.; Puffinus, Ray; Thalassidroma, Vig.

THE ORDERS, FAMILIES, AND SUB-FAMILIES OF BIRDS, ACCORDING TO THE SYSTEM OF MR SWAINSON.[1]

ORDER I.—RAPTORES. RAPACIOUS BIRDS.

FAMILY VULTURIDÆ. Vultures.

FAMILY FALCONIDÆ. Falcons.—Sub-families: Aquilinæ, Eagles; Cymindinæ, Kites; Buteoninæ, Buzzards; Falconinæ, Falcons; Accipitrinæ, Hawks.

FAMILY STRIGIDÆ. Owls.

ORDER II.—INSESSORES. PERCHING BIRDS.

Tribe I.—Dentirostres.

FAMILY LANIADÆ. Shrikes.—Sub-families: Lanianæ, True Shrikes; Thamnophilinæ, Bush Shrikes; Dicrurinæ, Drongo Shrikes; Ceblepyrinæ, Caterpillar-catchers; Tyranninæ, Tyrant Shrikes.

FAMILY MERULIDÆ. Thrushes.—Sub-families: Brachypodinæ, Short-footed Thrushes; Myotherinæ, Ant Thrushes; Merulinæ, True Thrushes; Crateropodinæ, Babblers; Oriolinæ, Orioles.

FAMILY SYLVIADÆ. Warblers.—Sub-families: Saxicolinæ, Stonechats; Philomelinæ, Nightingales; Sylvianæ, True Warblers; Parianæ, Tit-mice; Motacillinæ, Wagtails.

FAMILY AMPELIDÆ. Fruit-eaters, or Chatterers.—Sub-

[1] From the *Natural History and Classification of Birds*, vol. ii. p. 205, published in Dr Lardner's *Cabinet Cyclopædia*, vol. xcii. 1837. The accessible form of this recent work renders it less necessary that we should give a full exposition of its systematic portion, and the great amount of its generic groups renders their insertion somewhat incompatible with those prescribed limits which in truth we have already exceeded. But we take it for granted, that every sincere lover of Ornithology will possess himself of Mr Swainson's volumes, to which any abstract we could offer would do injustice.

Birds of Europe.

families: Leiotrichanæ, Silky Chatterers? Vireoninæ, Greenlets and Thick-heads; Bombycillinæ, Swallow-chatterers; Ampelinæ, Typical Chatterers; Piprinæ, Manakins.

Family Muscicapidæ. Fly-catchers.—Sub-families: Querulinæ; Psarianæ, Black-caps; Fluvicolinæ, Water-chats; Muscicapinæ, Fly-catchers; Eurylaiminæ, Broad-bills.

Tribe II.—Conirostres.

Family Corvidæ. Crows.—Sub-families: Corvinæ, Typical Crows; Garrulinæ, Jays; Glaucopinæ, Wattle-crows; Coracinæ, Fruit-crows; Frigilinæ.

Family Sturnidæ. Starlings.—Sub-families: Sturninæ, Typical Starlings; Lamprotorninæ, Grakles; Scaphidurinæ, Boat-tails; Icterinæ, Hang-nests; Aglainæ, Maizers.

Family Fringillidæ. Finches.—Sub-families: Coccothraustinæ, Hard-bills; Tanagrinæ, Tanagers; Fringillinæ, Ground-finches; Alaudinæ, Larks; Pyrrhulinæ, Bullfinches.

Family Musophagidæ. Plantain-eaters.—Sub-families: Phitotominæ, Plant-cutters; Colinæ, Colies; Musophaginæ, Plantain-eaters.

Family Buceridæ. Genus Buceros.

Tribe III.—Scansores.

Family Ramphastidæ. Toucans.

Family Psittacidæ. Parrots.—Sub-families: Macrocircinæ, Maccaws; Psittacinæ, Parrots; Plyctolophinæ, Cockatoos; Lorianæ, Lories; Platycircinæ, Loriets.

Family Picidæ. Woodpeckers.—Sub-families: Picianæ, True Woodpeckers; Buccoinæ, Barbuts.

Family Certhiadæ. Creepers.—Sub-families: Certhianæ, True Creepers; Anabatinæ, Tree-runners; Sittinæ, Nut-hatchers; Troglodytinæ, Wrens; Buphaginæ, Ox-peckers.

Family Cuculidæ. Cuckoos.—Sub-families: Cuculinæ, Parasitic Cuckoos; Coccyzinæ, Hook-billed Cuckoos; Leptostominæ, Long-billed Cuckoos; Indicatorinæ, Honey-guides.

Tribe IV.—Tenuirostres. Suctorial Birds.

Birds of Europe.

Family Meliphagidæ. Honey-suckers.
Family Cinnyridæ. Sun-birds.
Family Trochilidæ. Humming birds.
Family Promeropidæ. Hoopoes.
Family Paradisiadæ. Paradise Birds.

Tribe V.—Fissirostres. Fissirostral Birds.

Family Meropidæ. Bee-eaters.
Family Halcyonidæ. King-fishers.
Family Trogonidæ. Trogons.
Family Caprimulgidæ. Night-jars.
Family Hirundinidæ. Swallows.

Order III.—Rasores. Rasorial Birds.

Family Pavonidæ. Peacocks and Pheasants.
Family Tetraonidæ. Partridges and Grouse.
Family Struthionidæ. Ostriches.
Family Columbidæ. Pigeons.—Sub-family: Columbinæ.
Family Megapodiadæ. Great-foots.

Order IV.—Grallatores. Waders.

Family Ardeadæ. Herons and Cranes.
Family Tantalidæ. Ibis.
Family Rallidæ. Rails.
Family Scolopacidæ. Sand-pipers and Snipes.
Family Charadriadæ. Plovers.

Order V.—Natatores. Swimmers.

Family Anatidæ. Ducks.—Sub-families: Phænicoptinæ, Flamingoes; Anserinæ, Geese and Swans; Anatinæ, River-ducks; Fuligulinæ, Sea-ducks; Merganinæ, Mergansers.
Family Colymbidæ. Grebes and Divers.
Family Alcadæ. Auks.
Family Pelecanidæ. Pelicans.
Family Laridæ.[1] Gulls.

ENUMERATION OF THE BIRDS OF EUROPE.[2]

Order I.—Raptores.

Vultur fulvus, Linn.	Griffon Vulture.
V. cinereus, Linn.	Cinereous Vulture.
Neophron percnopterus, Sav.	Egyptian Neophron.
Gypaëtus barbatus, Storr.	Lammer-geyer.
Aquila imperialis, Briss.	Imperial Eagle.
A. chrysæta, Briss.	Golden Eagle.
A. Bonelli.	Bonelli's Eagle.
A. nævia, Meyer.	Spotted Eagle.
A. pennata, Steph.	Booted Eagle.
Haliæëtus albicilla, Selby.	Sea-Eagle.
H. leucocephalus, Sav.	White-headed Eagle.
Pandion haliæëtus, Sav.	Osprey.
Circætus brachydactylus, Vieill.	Short-toed Eagle.
Buteo vulgaris, Bechst.	Common Buzzard.
B. lagopus, Flem.	Rough-legged Buzzard.
Pernis apivorus, Cuv.	Honey Buzzard.
Astur palumbarius, Bechst.	Goshawk.
Falco islandicus, Lath.	Jer-Falcon.
F. lanarius, Linn.	Lanner Falcon.
Falco peregrinus, Linn.	Peregrine Falcon.
F. subbuteo, Linn.	Hobby.
F. rufipes, Bechst.	Red-footed Falcon.
F. æsalon, Temm.	Merlin.
F. concolor, Temm.	Lead-coloured Falcon.
F. tinnunculus, Linn.	Kestril.
F. tinnunculoides, Natt.	Lesser Kestril.
Milvus vulgaris, Flem.	Kite.
M. ater.	Black Kite.
Nauclerus furcatus, Vig.	Swallow-tailed Kite.
Elanus melanopterus, Leach.	Black-tailed Kite.

[1] This and the preceding family are placed as sub-families in Mr Swainson's synopsis,—we presume, by an oversight in typographical correction. A similar inadvertency occurs among the tenuirostral tribe.

[2] From Mr Gould's *Birds of Europe*, recently completed in five volumes royal folio, 1837. According to the author of this sumptuous work, the number of European birds may now be stated to amount to 462 species, of which 310 may be regarded as British. Of the latter, about 170 are permanent residents in our island, eighty-five are summer birds of passage, which visit us from the south, and forty-five are winter birds of passage, which visit us from the north. This seems to leave ten species unaccounted for: these may probably be regarded as accidental stragglers. We may add, that Mr Doubleday, in his *Nomenclature of British Birds* (1836), states the total number of species actually killed or captured in Britain as amounting to 323, of which the *Raptores* are thirty, the *Insessores* 117, the *Rasores* seventeen, the *Grallatores* sixty-six, and the *Natatores* ninety-three.

Birds of Europe.

Circus rufus, Briss.	Marsh Harrier.
C. cyaneus, Meyer.	Hen Harrier.
C. pallidus, Sykes.	Pallid Harrier.
C. cineraceus, Meyer.	Ash-coloured Harrier.
Strix flammea, Linn.	Barn Owl.
Bubo maximus, Sibb.	Great-horned or Eagle Owl.
B. ascalaphus, Sav.	Eastern Great-horned Owl.
Otus vulgaris, Flem.	Long-eared Owl.
O. brachyotus, Cuv.	Short-eared Owl.
Scops Aldrovandi, Will. and Ray.	Scops-eared Owl.
Surnia cinerea.	Great Cinereous Owl.
S. nyctea, Dum.	Snowy Owl.
S. Uralensis, Dum.	Ural Owl.
S. funerea, Dum.	Hawk Owl.
Ulula nebulosa, Cuv.	Barred Owl.
Syrnium aluco, Sav.	Tawny or Wood Owl.
Noctua nudipes, Wils.	Little Owl.
N. ? tengmalmi, Selby.	Tengmalm's Owl.
N. passerina.	Sparrow Owl.

ORDER II.—INSESSORES.[1]

Caprimulgus Europæus, Linn.	European Goat-sucker.
C. ruficollis.	Red-collared Goat-sucker.
Cypselus murarius, Temm.	Swift.
C. alpinus, Temm.	White-bellied Swift.
Hirundo rustica, Linn.	Chimney Swallow.
H. rufula, Temm.	Rufous Swallow.
H. rupestris, Linn.	Rock-Martin.
H. urbica, Linn.	Martin.
H. riparia, Linn.	Sand-Martin.
Merops apiaster, Linn.	Bee-eater.
Coracias garrulus, Linn.	Roller.
Alcedo ispida, Linn.	Kingfisher.
A. rudis, Linn.	Black and White Kingfisher.
Muscicapa luctuosa, Temm.	Pied Fly-catcher.
M. albicollis, Temm.	White-collared Fly-catcher.
M. parva, Bechst.	Red-breasted Fly-catcher.
M. grisola, Linn.	Spotted Fly-catcher.
Collurio excubitor, Vig.	Great Shrike.
C. meridionalis, Vig.	Great Gray Shrike.
C. minor, Vig.	Lesser Gray Shrike.
Lanius collurio, Linn.	Red-backed Shrike.
L. rufus, Briss.	Wood-Chat.
Oriolus galbula, Linn.	Golden Oriole.
Merula vulgaris, Ray.	Black Ouzel or Blackbird.
M. torquata, Briss.	Ring-Ouzel.
M. migratoria, Swains.	Migratory Ouzel.
Turdus atrogularis, Temm.	Black-throated Thrush.
T. pilaris, Linn.	Fieldfare.
T. viscivorus, Linn.	Missel-Thrush.
T. musicus, Linn.	Song-Thrush.
T. iliacus, Linn.	Redwing.
T. Naumannii, Temm.	Naumann's Thrush.
T. pallidus, Pall.	Pallid Thrush.
T. Whitei, Eyton.	White's Thrush.
T. Sibericus, Pall.	Siberian Thrush.
Cinclus aquaticus, Bechst.	Water-Ouzel.
C. melanogaster, Brehm.	Black-bellied Water-Ouzel.
C. Pallasii, Temm.	Pallas's Water-Ouzel.
Petrocincla saxatilis, Vig.	Rock-Thrush.
P. cyanea, Vig.	Blue Thrush.
Saxicola cachinnans, Temm.	Black Wheat-ear.
S. leucomela, Temm.	Pied Wheat-ear.
S. œnanthe, Bechst.	Wheat-ear.
S. stapazina, Temm.	Russet Wheat-ear.
S. aurita, Temm.	Black-eared Wheat-ear.
Saxicola rubetra, Bechst.	Whinchat.
S. rubicola, Bechst.	Stonechat.
Phœnicura ruticilla, Swains.	Redstart.
Ph. tithys, Jard. and Selb.	Black Redstart.
Ph. suecica, Jard. and Selb.	Blue-throated Warbler.
Erythaca rubecula, Swains.	Robin.
Accentor alpinus, Bechst.	Alpine Accentor.
A. modularis, Cuv.	Hedge Accentor.
A. montanellus, Temm.	Mountain Accentor.
Locustella fluviatilis.	Reed Locustelle.
L. avicula, Ray.	Brake Locustelle.
L. luscinoides.	Willow Locustelle.
L. certhiola.	Creeping Locustelle.
Salicaria turdoides, Selb.	Great Sedge Warbler.
S. olivetorum, Strickl.	Olive-tree Salicaria.
S. arundinacea, Selb.	Reed Wren.
S. palustris.	Marsh Warbler.
S. phragmitis, Selb.	Sedge Warbler.
S. melanopogon.	Moustached Warbler.
S. aquatica.	Aquatic Warbler.
S. galactotes.	Rufous Sedge Warbler.
S. cisticola.	Fan-tail Warbler.
S. ? Cetti.	Cetti's Warbler.
S. ? sericea.	Silky Warbler.
Philomela luscinia, Swains.	Nightingale.
Ph. turdoides, Blyth.	Thrush Nightingale.
Calliope Lathamii.	Gorget Warbler.
Curruca Orphea.	Orpheus Warbler.
C. atricapilla, Bechst.	Black-cap.
C. hortensis, Bechst.	Garden Warbler.
C. Rupellii.	Ruppell's Warbler.
C. melanocephala, Lath.	Sardinian Warbler.
C. leucopogon.	Sub-alpine Warbler.
C. cinerea, Bechst.	Common White-throat.
C. garrula, Bechst.	Lesser White-throat.
C. conspicillata.	Spectacle Warbler.
C. sarda.	Marmora's Warbler.
C. nisoria.	Barred Warbler.
Melizophilus provincialis, Leach.	Dartford Warbler.
Troglodytes Europæus, Cuv.	Wren.
Sylvia trochilus, Gmel.	Willow Wren.
S. rufa, Lath.	Chiff-Chaff.
S. sibilatrix, Bechst.	Wood Wren.
S. icterina, Vieill.	Yellow Willow Wren.
S. hippolais, Temm.	Melodious Willow Wren.
S. Nattereri, Temm.	Natterer's Warbler.
Anthus Richardi, Vieill.	Richard's Pipit.
A. pratensis, Bechst.	Meadow Pipit.
A. rufescens, Temm.	Tawny Pipit.
A. aquaticus, Bechst.	Rock or Shore Pipit.
A. arboreus, Bechst.	Tree Pipit.
A. rufogularis, Temm.	Red-throated Pipit.
Motacilla Yarrellii.	Pied Wagtail.
M. lugubris, Pall.	White-winged Wagtail.
M. alba, Linn.	White Wagtail.
M. neglecta, Gould.	Gray-headed Wagtail.
M. boarula, Lath.	Gray Wagtail.
Regulus ignicapillus, Cuv.	Fire-crested Wren.
R. vulgaris, Cuv.	Golden-crested Wren.
R. modestus.	Dalmatian Regulus.
Parus major, Linn.	Great Tit.
P. lugubris, Natt.	Sombre Tit.
P. Sibericus, Gmel.	Siberian Tit.
P. bicolor, Linn.	Toupet Tit.

[1] Including the SCANSORES of the preceding Treatise.

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Parus cyanus, Pall.	Azure Tit.
P. cæruleus, Linn.	Blue Tit.
P. ater, Linn.	Cole Tit.
P. palustris, Linn.	Marsh Tit.
P. cristatus, Linn.	Crested Tit.
P. caudatus, Linn.	Long-tailed Tit.
Calamophilus biarmicus, Leach.	Bearded Tit, or Reed Bird.
Œgithalus pendulinus, Vig.	Penduline Tit.
Bombycivora garrula, Temm.	Waxen Chatterer.
Alauda tartarica, Pall.	
A. calandra, Pall.	Calandra Lark.
A. brachydactyla, Temm.	Short-toed Lark.
A. alpestris, Linn.	Shore-Lark.
A. cristata, Linn.	Crested Lark.
A. arvensis, Linn.	Sky-Lark.
A. arborea, Linn.	Wood-Lark.
Certhilauda bifasciata.	Bifasciated Lark.
Plectrophanes Lapponica, Selb.	Lark-heeled Bunting.
Pl. nivalis, Meyer.	Snow-Bunting.
Emberiza miliaria, Linn.	Common Bunting.
E. melanocephala, Scop.	Black-headed Bunting.
E. citrinella, Linn.	Yellow Bunting.
E. aureola, Pall.	Yellow-breasted Bunting.
E. cirlus, Linn.	Cirl Bunting.
E. hortulana, Linn.	Ortolan Bunting.
E. rustica, Pall.	Rustic Bunting.
E. lesbia.	Lesbian Bunting.
E. cia, Linn.	Meadow-Bunting.
E. pithyornus, Pall.	Pine-Bunting.
E. cæsia, Cretz.	Cretzschmar's Bunting.
E. palustris, Savi.	Marsh-Bunting.
E. schœniculus, Linn.	Reed-Bunting.
Pyrgita domestica, Cuv.	Common Sparrow.
P. montana, Cuv.	Tree-Sparrow.
P. Hispaniolensis, Cuv.	Spanish Sparrow.
P. cisalpina, Cuv.	Alpine Sparrow.
P. petronia.	Doubtful Sparrow.
Fringilla cœlebs, Linn.	Chaffinch.
F. montifringilla, Linn.	Mountain or Bramble Finch.
F. nivalis, Linn.	Snow-Finch.
F. ? hyemalis.	Winter-Finch.
Linaria cannabina, Swains.	Common or Brown Linnet.
L. montana, Ray.	Mountain Linnet or Twite.
L. canescens.	Mealy Redpole.
L. minor, Ray.	Lesser Redpole.
Serinus flavescens.	Serin Finch.
Carduelis elegans, Steph.	Goldfinch.
C. spinus, Steph.	Siskin or Aberdevine.
C. citrinella.	Citril Finch.
Coccothraustes vulgaris, Briss.	Hawfinch.
C. chloris, Flem.	Green Grosbeak.
Loxia pityopsittacus, Bechst.	Parrot Crossbill.
L. curvirostra, Linn.	Common Crossbill.
L. leucoptera, Gmel.	White-winged Crossbill.
Corythus enucleator, Cuv.	Pine Grosbeak.
C. longicauda.	Siberian Grosbeak.
Erythrospiza erythrina, Bon.	Scarlet Grosbeak.
E. rosea.	Rosy Grosbeak.
E. githaginea.	Vinous Grosbeak.
Pyrrhula vulgaris, Temm.	Bullfinch.
Sturnus vulgaris, Linn.	Starling.
S. unicolor, Marm.	Sardinian Starling.
Pastor roseus, Temm.	Rose-coloured Pastor.
Nucifraga caryocatactes, Briss.	Nut-cracker.
Garrulus glandarius, Briss.	Jay.
G. infaustus, Temm.	Siberian Jay.
Pica caudata, Ray.	Magpie.
P. cyanea, Wagl.	Azure-winged Magpie.
Pyrrhocorax Pyrrhocorax, Temm.	Alpine Chough.
Fregilus graculus, Cuv.	Chough.
Corvus corax, Linn.	Raven.
C. corone, Linn.	Carrion Crow.
C. cornix, Linn.	Hooded Crow.
C. monedula, Linn.	Jackdaw.
C. frugilegus, Linn.	Rook.
Picus martius, Linn.	Great Black Woodpecker.
P. viridis, Linn.	Green Woodpecker.
P. canus, Gmel.	Gray-headed Green Woodpecker.
P. leuconotus, Bechst.	White-rumped Woodpecker.
P. major, Linn.	Great Spotted Woodpecker.
P. medius, Linn.	Middle Spotted Woodpecker.
P. minor, Linn.	Lesser Spotted Woodpecker.
Apternus tridactylus, Swains.	Three-toed Woodpecker.
Yunx torquilla, Linn.	Wryneck.
Sitta Europœa, Linn.	Common Nuthatch.
S. Syriaca, Ehrenb.	Dalmatian Nuthatch.
S. Asiatica, Temm.	Asiatic Nuthatch.
Certhia familiaris, Linn.	Common Creeper.
Upupa epops, Linn.	Hoopoe.
Tichodroma phœnicoptera, Temm.	Wall-Creeper.
Cuculus canorus, Linn.	Common Cuckoo.
C. glandarius, Linn.	Great Spotted Cuckoo.
Coccyzus Americanus, Vieill.	American Cuckoo.

Order III.—Rasores.

Columba palumbus, Linn.	Wood-Pigeon.
C. Œnas, Linn.	Stock-Dove.
C. livia, Linn.	Rock-Dove.
C. turtur, Linn.	Turtle-Dove.
Phasianus colchichus, Linn.	Common Pheasant.
Tetrao urogallus, Linn.	Capercailzie, or Cock of the Wood.
T. hybridus, Sparrm.	Hybrid Grouse.
T. tetrix, Linn.	Black Grouse.
Bonasia Europæa.	Hazel Grouse, or Gelinotte.
Lagopus Scoticus, Lath.	Red Grouse.
L. mutus, Leach.	Common Ptarmigan.
L. rupestris, Leach.	Rock Ptarmigan.
L. saliceti, Swains.	Willow Ptarmigan.
L. brachydactylus.	Short-toed Ptarmigan.
Pterocles arenarius, Temm.	Sand-Grouse.
P. setarius, Temm.	Pin-tailed Sand-Grouse.
Francolinus vulgaris, Briss.	European Francolin.
Perdix rubra, Ray.	Red-legged Partridge.
P. petrosa, Lath.	Barbary Partridge.
P. saxatilis, Meyer.	Greek Partridge.
P. cinerea, Lath.	Common Partridge.
Coturnix dactylisonans, Meyer.	Quail.
Hemipodius tachydromus, Temm.	Andalusian Turnix.
Glareola torquata, Briss.	Collared Pratincole.
Cursorius Isabellinus, Meyer.	Cream-coloured Courser.
Otis tarda, Linn.	Great Bustard.
O. houbara, Linn.	Ruffed Bustard.
O. tetrax.	Little Bustard.

Order IV.—Grallatores.

Grus cinerea, Bechst.	Common Crane.
G. leucogeranus, Temm.	White Crane.
Anthropoides virgo, Vieill.	Numidian Demoiselle.
Ardea cinerea, Lath.	Common Heron.

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- Ardea purpurea, Linn. — Purple Heron.
- A. comata, Pall. — Squacco Heron.
- A. alba, Linn. — Great Egret.
- A. garzetta, Linn. — Little Egret.
- A. russata, Wagl. — Rufous-backed Egret.
- Nycticorax Europæus, Steph. — Common Night-Heron.
- Botaurus stellaris, Steph. — Common Bittern.
- B. lentiginosus, Steph. — Freckled Bittern.
- B. minutus, Selby. — Little Bittern.
- Ciconia alba, Bellon. — White Stork.
- C. nigra, Bellon. — Black Stork.
- C. Maquari, Temm. — Maquari Stork.
- Platalea leucorodia, Linn. — Spoonbill.
- Phœnicopterus ruber, Linn. — Common Flamingo.
- Œdicnemus crepitans, Temm. — Thick-kneed Bustard.
- Himantopus melanopterus, Meyer. — Long-legged Plover.
- Squatarola cinerea, Cuv. — Gray Plover.
- Vanellus cristatus, Meyer. — Lapwing.
- V. Keptuschka, Temm. — Keptuschka Lapwing.
- Pluvianus spinosus. — Spur-winged Plover.
- Charadrius pluvialis, Linn. — Golden Plover.
- C. morinellus, Linn. — Dotterel.
- C. hiaticula, Linn. — Ring-Dotterel.
- C. minor, Meyer. — Little Ring-Dotterel.
- C. Cantianus, Linn. — Kentish Plover.
- C. pyrrhothorax, Temm. — Red-chested Dotterel.
- Hæmatopus ostralegus, Linn. — Oyster-Catcher.
- Ibis Falcinellus, Temm. — Glossy Ibis.
- Numenius arquata, Lath. — Common Curlew.
- N. Phæopus, Lath. — Whimbrel.
- N. tenuirostris, Sav. — Slender-billed Curlew.
- Limosa melanura, Leisl. — Black-tailed Godwit.
- L. rufa, Briss. — Bar-tailed Godwit.
- L. terek, Temm. — Terek Godwit.
- Recurvirostra Avocetta, Linn. — Avocet.
- Totanus fuscus, Leisl. — Spotted Redshank.
- T. calidris, Bechst. — Redshank.
- T. semipalmatus, Temm. — Semipalmated Sandpiper.
- T. glottis, Bechst. — Greenshank.
- T. Bartramius, Temm. — Bartram's Sandpiper.
- T. stagnatilis, Bechst. — Marsh Sandpiper.
- T. ochropus, Temm. — Green Sandpiper.
- T. glareola, Temm. — Wood Sandpiper.
- T. hypoleucus, Temm. — Common Sandpiper.
- T. macularius, Temm. — Spotted Sandpiper.
- Strepsilas collaris, Temm. — Turnstone.
- Scolopax rusticola, Linn. — Woodcock.
- S. major, Linn. — Great Snipe.
- S. Sabini, Vig. — Sabine's Snipe.
- S. gallinago, Linn. — Common Snipe.
- S. gallinula, Linn. — Jack Snipe.
- Macroramphus griseus, Leach. — Gray Snipe.
- Calidris canutus, Briss. and Cuv. — Knot.
- Machetes pugnax, Cuv. — Ruff.
- Tringa rufescens, Vieill. — Buff-breasted Sandpiper.
- T. pectoralis, Bonap. — Pectoral Sandpiper.
- T. subarquata, Temm. — Pygmy Curlew.
- T. variabilis, Meyer. — Dunlin or Purre.
- T. Schinzii, Bonap. — Schinz's Sandpiper.
- T. platyrhyncha, Temm. — Broad-billed Tringa.
- T. minuta, Leisl. — Little Sandpiper.
- T. Temminckii, Leisl. — Temminck's Tringa.
- T. maritima, Brunn. — Purple Sandpiper.
- Arenaria calidris, Meyer. — Sanderling.
- Phalaropus hyperboreus, Lath. — Red-necked Phalarope.
- Phalaropus platyrhynchus, Temm. — Gray Phalarope.
- Fulica atra, Linn. — Coot.
- Rallus aquaticus, Linn. — Water-Rail.
- Porphyrio hyacinthinus, Tem. — Hyacinthine Porphyrio.
- Gallinula crex, Lath. — Land-Rail.
- G. chloropus, Lath. — Common Gallinule.
- Zapornia porzana. — Spotted Crake.
- Z. Baillonii, Leach. — Baillon's Crake.
- Z. pusilla, Steph. — Little Crake.

Order V.—Natatores.

- Anser hyperboreus, Pall. — Snow-Goose.
- A. ferus, Steph. — Gray-Lag Wild Goose.
- A. segetum, Steph. — Bean Goose.
- A. albifrons, Steph. — White-fronted Goose.
- A. leucopsis, Bechst. — Bernicle Goose.
- A. ruficollis, Pall. — Red-breasted Goose.
- A. brenta, Flem. — Brent Goose.
- Chenalopex Ægyptiaca, Steph. — Egyptian Goose.
- Cygnus mansuetus, Gmel. — Domestic Swan.
- C. ferus, Ray. — Whistling Swan or Hooper.
- C. Bewickii, Yarr. — Bewick's Swan.
- Tadorna vulpanser, Flem. — Common Shieldrake.
- T. rutila, Steph. — Ruddy Shieldrake.
- Mareca Penelope, Selby. — Wigeon.
- Rhynchaspis clypeata, Steph. — Shoveller Duck.
- Anas Boschas, Linn. — Common Wild Duck.
- Querquedula Crecca, Steph. — Common Teal.
- Q. glocitans, Vig. — Bimaculated Teal.
- Q. circia, Steph. — Gargany Teal.
- Dafila caudacuta, Leach. — Pin-tail Duck.
- Chauliodes strepera, Swains. — Gadwall.
- Fuligula ferina, Steph. — Red-headed Pochard.
- F. leucophthalma, Steph. — White-eyed or Castaneous Duck.
- F. rufina, Steph. — Red-crested Duck.
- F. cristata, Steph. — Tufted Duck.
- F. marila, Steph. — Scaup Pochard.
- F. dispar, Steph. — Western Duck.
- F. marmorata. — Marbled Duck.
- Somateria mollissima, Leach. — Eider Duck.
- S. spectabilis, Leach. — King Duck.
- Oidemia perspicillata, Flem. — Surf Scoter.
- O. fusca, Flem. — Velvet Scoter.
- O. nigra, Flem. — Black Scoter.
- Clangula vulgaris, Leach. — Golden Eye.
- C. Barrovii, Sw. and Rich. — Barrow's Duck.
- C. histrionica, Leach. — Harlequin Duck.
- Harelda glacialis, Leach. — Long-tailed Duck.
- Undina leucocephala. — White-headed Duck.
- Mergus merganser, Linn. — Goosander.
- M. serrator, Linn. — Red-breasted Merganser.
- M. cucullatus, Linn. — Hooded Merganser.
- M. albellus, Linn. — Smew.
- Podiceps cristatus, Lath. — Great crested Grebe.
- P. rubricollis, Lath. — Red-necked Grebe.
- P. cornutus, Lath. — Horned Grebe.
- P. auritus, Lath. — Eared Grebe.
- P. minor, Lath. — Little Grebe, or Dabchick.
- Colymbus glacialis, Linn. — Northern Diver.
- C. arcticus, Linn. — Black-throated Diver.
- C. septentrionalis, Linn. — Red-throated Diver.
- Uria troile, Linn. — Foolish Guillemot.
- U. lachrymans, Lapyl. — Bridled Guillemot.
- U. Brunnichii, Sab. — Brunnick's Guillemot.
- U. grylle, Lath. — Black Guillemot.
- Alca impennis, Linn. — Great Auk.

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Ornithomancy || Orobio.

ORNITHOMANCY, a species of divination performed by means of birds, being the same with augury.

OROBIO, Don Balthasar, a celebrated Hebrew of Spain. He was carefully educated in Judaism by his parents, who were Jews, though they outwardly professed themselves Catholics; abstaining from the practice of their religion in every thing, except only the fast of expiation, in the month Tisis or September. Orobio studied the scholastic philosophy as taught in Spain, and became so skilled in it that he was appointed professor of metaphysics in the university of Salamanca. Afterwards, however, having applied himself to the study of physic, he practised with success that art at Seville, till, being accused of Judaism, he was thrown into the prison of the Inquisition, and suffered the most dreadful cruelties, in order to extort a confession. He tells us himself that he was put into a dark dungeon, so narrow that he could scarcely turn round in it; and he suffered so many hardships that his brain began to be disturbed. He talked to himself often in this way: "Am I indeed that Don Balthasar Orobio, who walked freely about in Seville, who was entirely at ease, and who had the blessings of a wife and children?" Sometimes he supposed that his past life had been but a dream, that the dungeon where he then lay was his true birthplace, and that it would to all appearance prove also the place of his death. At other times, as he had a very metaphysical head, he first formed arguments, and then resolved them; thus at once performing the different parts of opponent, respondent, and moderator. In this whimsical way he amused himself from time to time, and constantly denied that he was a Jew. After having appeared twice or thrice before the Inquisitors, his treatment was varied. At the bottom of a subterranean vault, lighted by two or three small torches, he was brought before two persons, one of them judge of the Inquisition, and the other secretary, who, having asked him whether he would confess the truth, protested, that in case of a criminal denial, the Holy Office would not be deemed the cause of his death, if he should expire under the torments, but that it must be imputed entirely to his own obstinacy. The executioner then stripped off his clothes, tied his feet and hands with a strong cord, and set him upon a little stool, whilst he passed the cord through some iron buckles which were fixed in the wall; after which, the stool having been drawn away, he remained hanging by the cord, which the executioner still drew tighter and tighter, to make him confess, till a surgeon assured the court of examiners that he could not possibly bear more without expiring. These cords put him to exquisite torture, by cutting into the flesh, and making the blood burst from under his nails. As there was certainly danger that the cords would tear off his flesh, care was taken to gird him about the breast with bands, which, however, were drawn so very tight that he would have run the risk of being suffocated, if he had not held in his breath whilst the executioner put the bands round him; by which device his lungs had room enough to perform their functions. In the agony of his sufferings, he was told that this was but the beginning of his torments, and that he would better confess before they proceeded to extremities. Orobio added further, that in order to frighten him, the executioner, placing himself on a small ladder, frequently let it fall against the shin-bones of his legs, and the staves being sharp, created exquisite pain. At last, after a confinement of three years, the Inquisitors, finding themselves baffled by his perseverance in denying his religion, ordered his wounds to be cured, and discharged him. As soon as he had obtained his liberty, he resolved to quit the Spanish dominions; and, proceeding to France, he was made professor of physic at Toulouse. The theses which he prepared as candidate for this place treated of putrefaction; and he maintained them with a metaphysical subtlety which embarrassed all his competitors. He resided for some time in this city, still outwardly professing the Catholic religion; but at last, weary of dissembling, he repaired to Amsterdam, where he was circumcised, took the name of Isaac, and professed Judaism, still continuing, however, to practise physic, in which he was much esteemed. Upon the publication of Spinoza's work, he began to despise a system the falsehood of which he quickly discovered; and when Bredenburg's answer to it came to his hands, Orobio, being persuaded that the writer, in refuting Spinoza, had also admitted some principles which tended to atheism, took up his pen against both, and published a piece entitled *Certamen Philosophicum*. But the dispute in which he engaged with the celebrated Philip Limborch against the Christian religion made the greatest noise. In this he exerted the utmost force of his metaphysical genius, and conducted himself with great temper. The three papers which he wrote on the occasion were afterwards printed by his antagonist, in an account which he published of the controversy, under the title of *Amica Collatio cum Judæo*. Orobio died in the year 1687.

Orontes || Orotava.

ORONTES, a river of Syria, which has its rise near a small hill at the foot of Mount Lebanon, to the north of Damascus, not far from the source of the Jordan. The two rivers flow in opposite directions; the latter southward to Lake Asphaltites, the former to the north, till, near Antioch, it makes a circuit to the west and south, and falls into the sea. The waters of the Orontes, at their source, are said to issue out in a large stream from the solid rock. It then takes a bend eastward, receiving several smaller streams in its course, till at last it winds along to the north-east, through the plains of Khoms and Khamah, about a hundred miles from its source. It soon increases to a considerable size, and swells out suddenly into a large lake, extending at least five miles to the north-east, and in some places nearly two miles wide. It is contracted in some parts between narrow and steep banks; and its course is deep and rapid, being scarcely less than four miles an hour. Its waters are a dull yellowish white, from the clayey and chalky soil of its banks in the lake above. At Antioch, where it falls into the sea, it is stated by Buckingham to be from 100 to 150 feet wide, and its stream flows at the rate of about three miles an hour. Such is the parched nature of the climate, that it would be often dry were it not for the bars of sand which obstruct its course, and allow the water to accumulate. Its stream is very deeply sunk amongst rocks, and it can only be rendered subservient to the purposes of irrigation by being laboriously raised with wheels. It forms three lakes, the Bahr-el-Kades, that of Famie or Apamea, and that of Antioch. By means of this river and the Euphrates, it is thought that a shorter route to India, nearly navigable all the way, might be effected; and an expedition was sent out by the British government in 1835, under Colonel Chesney, to explore the navigation of the Euphrates for this purpose.

OROPESA, a town of Bolivia, in South America, in the department of Cochabamba. The district in which it is situated is so well irrigated by rivers and streams, that it yields immense harvests of grain and other agricultural products. Oropesa, formerly the capital, and still a considerable place, is situated in a beautiful and fertile valley, on the borders of a small stream, one of the tributaries of the Rio Grande. The chief occupation of its inhabitants consists in supplying the neighbouring provinces with fruits and grain. The climate is mild and salubrious. Oropesa stands in long. 67. 6. west, and lat. 18. 15. south. This is likewise the name of a small town of Cuzco, in Peru.

OROTAVA, a town of Teneriffe, one of the Canary Islands, in the North Atlantic Ocean. It is situated on a very steep declivity, and, from the great abundance of wa-

Orpheoreon || Orpheus.

ter which runs through the principal streets, it has a very pleasant appearance at a distance. The spring of Agua Mansa, collected into two large reservoirs, turns several mills, and is afterwards distributed amongst the vineyards of the adjacent hills. Orotava is the ancient Taoro of the Guanches. The houses are substantially built, but have a gloomy appearance; and the streets seem as if deserted. Near this town is the celebrated dragon-tree of Orotava, one of the most gigantic productions of the kind on the face of the globe. Its circumference near the roots is forty-five feet. Although Santa Cruz is the principal seaport, and the capital of Teneriffe, the riches and fertility of the island are to be found at Orotava; and here the wine is chiefly made, and also shipped when the weather allows.

ORPHEOREON, an instrument of the lute kind, and strung with eight wires. It is no longer used.

ORPHEUS, a celebrated poet and musician, who lived at such an early period that his history is involved in fable, and many doubt if we have any facts respecting him on which dependence can be placed. According to the common mythology, he was a native of Thrace, being born in a cave at Pimpleia, a city of Pieria, which was then included in Thrace (Schol. Apollon. i. 25; Strab. vii. 330, x. 471). He is said to have been son of Apollo, or of Œagrus, king of Thrace, and of the muse Calliope (Diodor. iii. 64). He was the brother of Linus (Apollodor. ii. 4, 9), and the pupil of Musæus (Clemens. Strom. i. p. 332), or his master (Syncel., p. 156; Paus. x. 7, 1; Suid.). He is placed by Eusebius eighty-five years before the fall of Troy. He visited Egypt, and was there initiated in all the learning of the priests. When he returned to Thrace, he instituted the mysteries of Bacchus, which, according to Herodotus (ii. 81), included opinions which were afterwards promulgated by Pythagoras. He studied also under the Dactyli Idæi of Crete (Diodor. v. 64), and was the friend and companion of Cadmus, the founder of Thebes. He took a distinguished part in the Argonautic expedition, and saved his companions from the fascination of the Sirens (Apollodor. i. 9, 25). On the death of his wife Eurydice, he is said to have visited the infernal regions, and, through the intercession of Proserpine, obtained permission from Pluto that Eurydice should return with him to earth, provided he would engage not to look on her till he reached the earth. He broke his promise, and Eurydice instantly disappeared (i. 3, 2). How and where he died is variously stated. Some say that he died of grief for the loss of Eurydice; others allege that he was killed by lightning, because he revealed to man what the gods intended should be concealed from them; or that he was torn to pieces by the Mænades of Thrace, for some disrepect shown to Bacchus. Olympus, Pangæus, and Hæmus, are all named as the place of his catastrophe. The poets indicated the sweetness of his music by feigning that it was capable of moving the very stones and trees. Lucian tells a story of the head and lyre of Orpheus being thrown by the Thracian women into the Hebrus, and, as it floated down, the head was heaved by the water on the lyre, and sent forth, as it glided along, doleful strains. The head and lyre having reached the island of Lesbos, the former was buried on the spot where the temple of Bacchus afterwards stood, and the lyre was long preserved in the temple of Apollo. According to Eratosthenes (*Catast.* 24), it was placed by Jupiter in the heavens, and formed the constellation called Lyra.

There can be no doubt that there was an early poet of this name, but Aristotle considered all the works which were circulated under his name as spurious (Cic. *De Nat. Deor.* i. 38); and Cicero ascribes them to Cercops, a Pythagorean, or to Onomacritus (Clemens. *l. c.*). The hymn to Jupiter, quoted by Stobæus (p. 40), is certainly very ancient, as it is alluded to by Aristotle (*De Mund. Op.* t. i. p. 475), and is not to be confounded with the productions of the later Platonic school, which we have under the title of the Orphic hymns. These hymns present a mixture of the theological ideas of the Greeks, Jews, and even Christians, so that there can be no doubt of the period in which they were written.

Orpiment || Orthography.

ORPIMENT (*auripigmentum*), a mineral composed of sulphur and arsenic, found native in the earth, and constituting one of the ores of arsenic, but sometimes artificially prepared.

ORRERY, a curious machine for representing the motions or phases of the heavenly bodies. The reason of its being called an Orrery was this: Mr Rowley, a mathematical-instrument maker, having got one from Mr George Graham, the original inventor, to be sent abroad with some of his own instruments, he copied it, and made the first for the Earl of Orrery. Sir Richard Steele, who knew nothing of Mr Graham's machines, thinking to do justice to the first encourager, as well as to the inventor of such a curious instrument, called it an Orrery, and gave Mr Rowley the praise which was due only to Mr Graham.

ORSKAIA, a town of Asiatic Russia, in the government of Orenburg, situated on the Or, about a mile and a half before its junction with the Oural. The Asiatic caravans usually pass this river here in their way to Orenburg. The town of Orenburg was originally built upon this spot. Orskaia is 132 miles east of Orenburg

ORTEGAL, Cape, the most northern promontory of Spain, where there is also a castle of the same name. Long. 8. 20. W. Lat. 44. 0. N.

ORTELIUS, Abraham, a celebrated geographer, born at Antwerp in the year 1527. He was well skilled in languages and the mathematics, and acquired such reputation by his knowledge in geography, that he was surnamed the Ptolemy of his time. Justus Lipsius, and most of the great men of the sixteenth century, were the friends of Ortelius. He resided at Oxford in the reign of Edward VI. and came a second time into England in 1577. His *Theatrum Orbis* was the most complete work of the kind which had yet been published, and gained him a reputation equal to the immense labour bestowed in compiling it. He also wrote several other geographical works, the principal of which are his *Thesaurus*, and his *Synonyma Geographica*. The world is likewise indebted to him for the *Britannia*, which he persuaded Camden to undertake. He died at Antwerp in the year 1598.

ORTHEZ, an arrondissement of the department of the Lower Pyrenees, in France, 436 square miles in extent, containing seven cantons, 152 communes, and 87,495 inhabitants. The capital is the city of the same name, situated on the Gave de Pau. In the year 1836 it contained 7857 inhabitants, who are occupied in making flannels and other woollen goods, and in tanning leather. A great quantity of hams are cured here, and sold under the name of Bayonne hams. It has been rendered remarkable by a victory which the Duke of Wellington gained there over the French army. Long. 0. 50. W. Lat. 43. 32. N.

ORTHODOX, in *Ecclesiastical History*, an appellation given to those who are sound in all the articles of the Christian faith.

ORTHOGRAPHIC Projection of the Sphere, that in which the eye is supposed to be at an infinite distance. It is so called, because the perpendiculars, from any point of the sphere, will all fall in the common intersection of the sphere with the plane of the projection.

ORTHOGRAPHY, that part of grammar which teaches the nature and affections of letters, and the just method of spelling or writing words, with all the proper and necessary letters. It forms one of the four great divisions or branches of grammar.

Orthography, in *Geometry*, the art of drawing or delineating the fore-right plan of any object, and of express-

Orthography ‖ Orvieto.

ing the heights or elevations of each part. It is called *orthography*, from its determining things by perpendicular lines falling on the geometrical plane.

ORTHOGRAPHY, in *Architecture*, is the elevation of a building or edifice.

ORTHOGRAPHY, in *Perspective*, is the fore-right side of any plane, that is, the side or plane which lies parallel to a straight line, that may be imagined to pass through the outward convex points of the eyes, continued to a convenient length.

ORTHOPNŒA, a species or degree of asthma, where there is such a difficulty of respiration that the patient is obliged either to sit or stand upright in order to be able to breathe.

ORTHOSA, or ORTOSO, a small seaport of Syria, in the pachalik of Tripoli, on the coast of the Mediterranean, about twelve miles north of Tripoli.

ORTIVE, in *Astronomy*, the same with eastern. The ortive or eastern amplitude, is an arch of the horizon intercepted between the place where a star rises, and the east point of the horizon, or point where the horizon and equator intersect.

ORTON, a market-town of the county of Westmoreland, in the east ward, 274 miles from London, and eight from Appleby. It has a market, which is held on Wednesday. Dr Burn, the author of the "Justice," and of some antiquarian local works, was long vicar of the parish church, a very large old building. The population in 1801 amounted to 1230, in 1811 to 1333, in 1821 to 1525, and in 1831 to 1501.

ORTONE A MARE, a city of Italy, on the sea-shore, in the province of Abbruzzo Citeriore, of the kingdom of Naples. It is situated near to Cape Aquabella, is surrounded with walls, is the see of a bishop, and contains 5680 inhabitants. It has no haven, but a good roadstead.

ORURO, the name of a department, and also of a province, of the republic of Bolivia, in South America. The department so called contains the three provinces of Paria, Oruro, and Caraugas. The whole district forms part of a very high table-land, perfectly level, and elevated more than 12,000 feet above the level of the sea. The province is bounded on the east by Cochabamba and Charcas; on the west by part of the great chain of the Andes, which separates it from Arequipa; on the north by La Paz; and on the south by Paria. That part of the Bolivian Andes in which Oruro is situated forms one of those metalliferous groups which are so common along the whole mountain chain. The silver mines here were formerly very rich and productive, but they are now nearly useless, being filled with water, which, in a country where machinery is little in use, proves an almost insurmountable barrier to mining operations. The city of Oruro stands in longitude 68. 17. W. and latitude 17. 58. S., at an elevation of 12,441 feet above the level of the sea. The climate, although cold, is by no means unhealthy; but, from the rarity of the atmosphere, some difficulty of breathing is at first experienced by those who are not accustomed to respire at such altitudes, and the alternations of heat and cold during a single day are exceedingly disagreeable to all. The city and province of Oruro were formerly populous, but since the unfortunate struggle for Peruvian independence under Tupac Amaru, which was put an end to in the year 1782, the aboriginal population in particular has very considerably declined. The province contains about 15,000, and the city between 4000 and 5000 inhabitants.

ORVIETO, a city of Italy, in the delegation Viterbo, in the papal dominions. It stands on a tuffstein rock, on the banks of the Paglia, and has a magnificent cathedral with some very fine paintings, a noble episcopal palace, with several other churches, and fourteen convents or monasteries for the professed of both sexes. It contains 7800 inhabitants, who are employed in the silk and other trades, and who produce excellent wine. Long. 12. 2. 26. E. Lat. 42. 49. 24. N.

Osacca ‖ Oschophoria.

OSACCA, a large city of Japan, the port of Meaco. It is situated at the mouth of a considerable river, and at the head of a bay of the same name. It is the seat of an extensive trade, and one of the most flourishing cities of the empire. A quantity of earth is found in the neighbourhood, which is exported to all parts of Japan. It is twenty-five miles south-west of Meaco.

OSAGE, a large river of North America, and one of the affluents of the Missouri. (See the article MISSOURI.) This is also the name of a tribe of Indians who inhabit that part of the Missouri territory through which the river flows during the first part of its course. They likewise extend across the country to the Arkansas, and even to Red River, and are considered as a powerful tribe.

OSARA, or ASARA, a village in the Syrian desert, near the Euphrates, 170 miles east-south-east of Aleppo.

OSCHA, a river of Asiatic Russia, which falls into the Irtysch, in the government of Tobolsk.

OSCHOPHORIA, a festival celebrated by the Athenians, and which receives its name ἀπο του φερειν τας ὀσχας, *from carrying boughs hung with grapes*, which were called ὀσχαι. The original institution is mentioned by Plutarch. Theseus, on returning from Crete, forgot to hang out the white sail, by which his father was to be apprized of his success. This neglect proved fatal to Ægeus, who threw himself into the sea, and perished. Theseus no sooner reached the land, than he sent a herald to inform his father of his safe return, and in the mean time he began to perform the sacrifices which he had vowed to make when he first set sail from Crete. The herald, on his entrance into the city, found the people in great agitation. Some lamented the king's death, whilst others, elated at the sudden news of the victory of Theseus, crowned the herald with garlands in token of their joy. The herald carried back the garlands on his staff to the sea-shore; and, after waiting until Theseus had finished his sacrifice, he related the melancholy account of the king's death; upon which the people ran in crowds to the city, showing their grief by cries and lamentations. From this circumstance, therefore, at the feast of Oschophoria, not the herald, but his staff, was crowned with garlands, and the people who were present exclaimed ἐλελευ, ἰου, ἰου, the first of which expresses haste, and the others consternation or depression of spirits. The same author further mentions, that Theseus, when he went to Crete, did not take with him the usual number of virgins, but that instead of two of them, he took youths of his own acquaintance, whom he caused to pass for women, by changing their dress, and accustoming them to the ointments and perfumes of women, as well as by a long and successful imitation of the female voice. The imposition succeeded. Their sex was not discovered in Crete; and when Theseus had triumphed over the Minotaur, he with these two young men led a procession with branches in their hands, and wearing the same habits, which were afterwards worn at the celebration of the festival. The branches they carried were in honour of Bacchus or Ariadne, or because they returned in autumn, when the grapes were ripe. Besides this procession, there was also a race, in which young men only whose parents were both alive had permission to engage. It was customary for them to run from the temple of Bacchus to that of Minerva, which was on the sea-shore. The place where they stopped was called ὀσχοφοριου, because the boughs which they carried in their hands were there deposited. The reward of the conqueror was a cup called πενταπλοα, *five-fold*, because it contained a mixture of five different ingredients, wine, honey, cheese, meal, and oil.

Osenoka || Osiris.

OSENOKA, a small river of Asiatic Russia, which falls into the Kolyma.

OSENEY Island, in England, is formed by the river Isis, in the meadows near Oxford, where a magnificent abbey was erected at the instigation of a concubine of Henry I. to atone for her sins; and the same king built a palace there, in which Richard I. was born, and which Edward II. converted into a monastery.

OSILO, a city of the island of Sardinia, in the diocese of Tassari, in the northern division. It stands on the top of a mountain, in a very healthy situation, and contains 5430 inhabitants.

OSIMO, a city of Italy, in the delegation of Ancona, in the papal dominions. It is situated on an elevated and healthy situation, with most picturesque scenery around it. It is the see of a bishop, and has a cathedral and various other churches, as well as monastic establishments for both sexes, and is inhabited, besides, by several families of considerable wealth. There is a college and some learned societies, and a population of 11,750 persons, who subsist on their estates, or by agricultural labour.

OSIRIS, in *Mythology*, one of the gods of ancient Egypt, and by many believed to have been the Sun, or at least the mind actuating that luminary.

The Egyptians derived all things from two principles; one active, and the other passive. Their active principle, according to Jablonski, was an infinite and eternal Spirit; and their passive principle was Night. This spirit they considered sometimes as a male, sometimes as a female divinity, and occasionally they attributed to it both sexes; but it does not appear to have been the object of their worship. The earliest objects of Pagan adoration were the sun, moon, and planets; and that the philosophers and priests of ancient Egypt worshipped the Sun by the name of Osiris, may be proved by numberless testimonies from the most authentic records of antiquity. Diogenes Laertius affirms, that they held the Sun and Moon as divinities, and that they called the latter Isis; and Macrobius says expressly, "Nec in occulto est, neque aliud esse Osirin quam Solem, nec Isim aliud esse quam Terram." The same writer informs us, that in the hieroglyphical writings of ancient Egypt, "Osiris was represented by a sceptre and an eye," to denote that this god was the Sun looking down from heaven on all things upon earth. In the hieroglyphical inscriptions the symbol of Osiris is an eye surmounting a chair or throne.

It must not, however, be concealed, that some of the ancients, and a few of the most learned of the moderns, have contended, that by Osiris the Egyptians understood the Nile or spirit of the Nile, whilst others have confounded him with the Grecian Bacchus. Scaliger and Selden have adopted the former of these opinions, and Servius on Virgil has given countenance to the latter. But that they are all mistaken has been proved by Jablonski in such a manner as to enforce the fullest conviction. "When the Egyptians," says he, "in their sacred books, sometimes gave the name of Osiris to the Nile and its wonderful increase during the heat of summer, they meant nothing more than to attribute to their god Osiris the gift which fertilizes their country." This they would the more readily have done, because they believed the Nile to have its source in heaven. Hence Eusebius tells us, Οσιρις ἐστιν ὁ Νειλος, ὃν ἐξ ὐρανου καταφερεσθαι διονται, *Osiris is the Nile, because they think it is sent down from heaven.* In one sense Osiris might be Bacchus, because the original Bacchus was himself the Sun; but that the Egyptian god could not be worshipped as the inventor of wine is undeniable, if, as Jablonski labours to prove, the primitive religion of that country inculcated upon its votaries that wine was the gift, not of a benevolent god, but of an evil genius, the enemy of the human race. In support of this opinion he quotes from Plutarch a passage, whence it appears, that, before the era of Psammetichus, the Egyptians neither drank wine themselves, nor offered it in libations to the gods; because they believed that the first vine which sprung from the earth was impregnated by the blood of those giants who perished in the war with the gods. It is indeed true, that the Greeks, who borrowed their religion as well as the first principles of their science from Egypt, attributed to Bacchus many of the actions of Osiris; but it is likewise true, that they ascribed to him other attributes, which the Egyptian god could not possess, consistently with the established superstitions of that country. Salmasius, however, attempts to prove, from the import of the name, that the Osiris of Egypt must have been the Bacchus of Greece. Σηρ, or Σιρι, he says, signifies *a son* in the Egyptian language; and hence he concludes that the god was called Osiris by the Egyptians, for the same reason that by the Greeks he was called Κουρος, and by the Romans *Liber*. But this seems to be all a mistake. *Siris* forms a part of many Egyptian proper names, as *Bu-siris*, *Thermo-siris*, *Tapo-siris*, and the like, and is by some derived from the Hebrew word *Sar*, *Sur*, or *Sir*, which signifies a prince, potentate, or grandee. As the name of the god was in Egypt not Osiris, but *Isiris*, or *Ysiris*, it was probably composed of *Sir* or *Siris*, and the Hebrew prefix *I* or *ish*, denoting strength; so that the whole word would signify the strong or mighty prince. And if so, we cannot doubt, as Diodorus Siculus, Eusebius, Sextus Empiricus, and others affirm, that the Egyptians worshipped the Sun by the name of Osiris, but that by this name they meant the power or governing mind of the Sun, as the Greeks and Romans seem to have done by their Phœbus and Apollo.

Osiris.

But although the original Osiris was undoubtedly the Sun, or the intelligence actuating the Sun, yet there is reason to believe that there was a secondary Osiris, who at a very early period reigned in Egypt, and was deified after his death, for the benefits which he had rendered to his country. This is indeed so generally admitted, that amongst the learned great controversies have arisen respecting the time when he flourished, and whether he was the civilizer of rude barbarians or the victorious sovereign of a polished nation. Newton, it is well known, has adopted the latter opinion, and with much plausibility endeavoured to prove that Osiris was the same with Sesostris or Sesak; but it must be confessed that his conclusion is contrary to all the most authentic records of antiquity, and that it would be easy, by the same mode of arguing, to give a show of identity to two persons universally known to have flourished in very distant ages. The annals of Egypt, as may be seen in the writings of Herodotus, Diodorus Siculus, Strabo, Plutarch, and others, who copied from them, expressly asserted the distinct personality of Osiris and Sesostris, and placed them in eras very distant from each other. If any credit be due to the historians just named, Osiris was the founder of the Egyptian monarchy; and, as was customary in those days, the same personage, having either received the name of the Sun, or communicated his own to that luminary, was after his death deified for the benefits which he had rendered to his country; and, being at first worshipped only as a demigod, was in process of time advanced to full divinity, and confounded with his heavenly godfather. The Greeks, who, although original in nothing, were always prompted by their vanity to hold themselves out as the first of the nations, claimed this Osiris as their own, and pretended that he was the son of Jupiter and Niobe. According to them, he reigned over the Argives; but afterwards, having delivered his kingdom to his brother Aigialeus, took a voyage into Egypt, of which he made himself master, and there married Io or Isis. He established many good laws in

Oskol-Staroi ‖ Osorius.

that country, and both Osiris and Isis were after their deaths worshipped as gods. But that this is a ridiculous fiction needs no proof; because every one knows that good laws were established in Egypt long before the Argives had any king, or indeed existed either as a tribe or a nation.

OSKOL-STAROI, a city of Russia, in the government of Kursk, the capital of a circle of the same name. It stands at the mouth of the river Oskolka, and has eight churches, a nunnery, 813 houses, and 6000 inhabitants, amongst whom many are occupied in the iron trade. It is 904 miles from St Petersburg. Long. 37. 29. E. Lat. 51. 15. N.

OSMANJIC, a town of Asiatic Turkey, in the government of Sivas, 140 miles north-west of Sivas.

OSMANSKOI, a small town of Asiatic Russia, in the government of Kolivan, on the Irtysch, 201 miles west-south-west of Kolivan.

OSNABRUCK, or Osnaburg, a province of the kingdom of Hanover. It has been formed out of the ancient sequestered bishopric of that name, which by the treaty of Westphalia had been fixed to be held in sovereignty alternately by a Catholic and a Protestant prince; and in consequence it came under the government of the late Duke of York, second son of George III. To the bishopric has been added by cession the Prussian bailiwick of Beckenburg, the lower county of Lingen, and the circles of Meppen and Emsbuhren. It is bounded on the north by East Friesland, on the north-east by Oldenburg and Diepholz, on the south-east and south-west by the Prussian province of Westphalia, and on the west by Bentheim. It extends over 1288 square miles, contains twenty towns and cities, 382 villages, with 249,470 inhabitants, of whom two thirds are Catholics, and the other third Protestants, chiefly of the Lutheran confession. It is generally a level and sandy district, excepting on the southern part, where there are two ranges of hills. Near these the soil is tolerably fertile; but on the other parts, except near the rivers, it is very poor and unproductive. The heaths are extensive, and a large portion of the province is covered with woods. The corn produced, even with the aid of extensive cultivation of potatoes, is not sufficient for the consumption. Flax is grown largely, and the spinning of it was the chief employment of the country people of both sexes during their long winters; but that occupation has been much diminished by the introduction of spinning by machinery in the countries which used to obtain their yarn from this province. Numerous bodies of the agricultural labourers repair to Holland to work, and some after harvest return home to live upon their earnings; but many of them remain to perform the lowest kinds of labour in Amsterdam, Rotterdam, and other cities, and many also enlist into the Dutch army. The province is formed into four divisions or circles, viz. Osnabruck, Lingen, Meppen, and Emsbuhren.

Osnabruck as it is called by the Germans, or Osnaburg as it is spelt by us, is the capital of the province. It is situated on the river Hase, is imperfectly fortified, and consists chiefly of one very long and not ill-built street, divided into the old and the new town. It is the see of a Catholic bishop, who has a palace and a cathedral; and there is a fine old council-house, in which the treaty of Westphalia was negotiated. It has two Catholic monasteries, a Lutheran gymnasium, two Lutheran churches, and one, besides the cathedral, for the Catholics. It contains about 1400 houses, and 10,500 inhabitants, who depend chiefly on the decaying linen trade, and on internal commerce. Long. 7. 33. 40. E. Lat. 52. 16. 45. N.

OSORIUS, Jerome, a Portuguese ecclesiastic, was descended of a noble family, and born at Lisbon in the year 1500. He was educated at the University of Salamanca, and afterwards studied at Paris and Bologna. On his return to Portugal he gradually rose till he obtained the bishopric of Sylves, to which he was appointed by Catharine of Austria, regent of the kingdom in the minority of Dom Sebastian. At the request of Cardinal Henry of Portugal, he wrote his history of King Emanuel, and the expedition of Gama, which his great contemporary Camoens made the subject of his Lusiad. It is remarkable that the history of Osorius and the epic poem of Camoens were published in the same year, 1572. But the fate of these two great authors was very different. The poet was suffered to perish in poverty, under the reign of that same Henry who patronised the historian; yet, allowing for the difference of their professions, they possessed a certain similarity of mind. Even in the priest Osorius there appear many traces of that high and heroic spirit which animated the soldier Camoens, particularly in the pleasure with which he seems to describe the martial manners of his countrymen under the reign of Emanuel. "In that age," says he, "poverty and sadness were banished from Portugal. Complaints were never heard; but every place, from the court to the cottage, resounded with mirth and music. Illicit love was unknown; nor would the ladies listen to the most honourable addresses of such youths as had not signalized themselves in war. No young man about court, however noble by birth, was permitted to wear the dress of manhood till he had passed over into Africa, and thence brought back with him some animal esteemed for its rarity; and such was the hardy education of the nobility in that age, that many of them travelled everywhere in quest of adventures." This is a striking picture of the manners of chivalry, to which Portugal owed much of its glory in that splendid period. There is one particular in the character of Osorius, which, considering his age and country, deserves the highest encomium; and that is his tolerant spirit. In the first book of his history he speaks of Emanuel's cruel persecution of the Jews in the following generous and exalted language: "This," says he, "was authorized neither by law nor by religion. Can men be compelled to believe what they reject with abhorrence? Do you take upon you to restrain the liberty of the will, or to fetter the understanding? Such an attempt must be unsuccessful; and is not acceptable to Christ, who expects from man devotion of the heart, and not that formal worship which is the offspring of pains and penalties. He wishes them to study his religion, and accept it from conviction, not from terror; for who does not see that forced belief is mere hypocrisy?" Osorius is said to have used many arguments to dissuade Dom Sebastian from undertaking his unfortunate expedition into Africa, and to have felt so deeply the miseries which befell the Portuguese after that fatal event, that his grief was supposed to have accelerated his death. He died in the year 1580, happy, says De Thou, who celebrates him as a model of Christian virtue, that he died just before the Spanish army entered Portugal, and thus escaped being a witness to the desolation of his country. His various works were published at Rome in 1592, by his nephew Osorius, in four volumes folio, with a life of their author. Amongst these there are two remarkable productions; the first, an Admonition to Queen Elizabeth, exhorting her to return into the bosom of the Church of Rome; and the second, an Essay on Glory, written with such classical purity, as to give birth to a report that it was not the composition of Osorius, but the last work of Cicero on that subject.

Ossa.

OSSA, a lofty mountain of Thessaly, near the Peneus, which runs between this mountain and Olympus; it was famous in the fabulous story of the giants.

Ossa, a town of the island of Gilolo, situated on the southern side of a great bay of the same name. It affords water, provisions, timber for spars, and other necessary ar-

D'Ossat. ticles, with which ships touching at the island are supplied. Long. 128. 22. E. Lat. 0. 45. S.

OSSAT, Arnaud d', a celebrated cardinal, and one of the most remarkable men of his time, was born at Laroque-en-Magnoac, a village in the diocese of Auch, in the year 1536. In the strictest sense of the Spanish expression, he was "the son of his own works." There is reason to believe that his father, who died in distress in Spain, exercised the profession of farrier; and this opinion is in accordance with the common tradition, according to which D'Ossat was ushered into the world by an army-farrier. At the age of nine, he found himself without any known parents, and having no other resource than public charity. But a gentleman of the neighbourhood, named De Marca, received the orphan into his house, and caused him to be educated along with one of his nephews, who had been committed to his care. In this situation the progress of D'Ossat was so striking, that in a very few years he was thought capable of acting as preceptor to the companion of his studies. In 1559 he received orders to attend his pupil, and two other nephews of M. de Marca, to Paris; and he was likewise intrusted with the charge of a son of a merchant in Lectoure, who accompanied them. To these youths he devoted the utmost care and attention till the year 1562, when, having completed their course of study, they returned to their relations; thus relieving him from those extrinsic duties, the performance of which had impeded his own progress, and prevented him from increasing at pleasure the amount of his own acquirements. During this period, however, he had studied rhetoric and philosophy, and, in particular, had profited by the lessons of Ramus, whose bold and penetrating mind had enabled him to strike into new paths of inquiry. Hence, when Charpentier, the fierce champion of Aristotle, attacked Ramus, D'Ossat defended the doctrine of his master in a judicious production, entitled *Expositio in Disputationem Jacobi Carpenterii de Methodo*, Paris, 1564, in 8vo, the elegant and close dialectics of which so disconcerted Charpentier, that the only answer he could make to his adversary consisted in scurrility and abuse. D'Ossat quitted Ramus to study the civil law under Cujas in the university of Bourges. His intention was to qualify himself for the profession of advocate; and accordingly, having taken his diploma, he returned to Paris in the year 1568, and was admitted to the bar. But being as yet almost unknown, and without the means necessary to enable him to wait for employment in the ordinary course of the profession, he had not long attended the sittings of the parliament of Paris ere he became convinced that he would never find his place amidst so much that was arbitrary on the bench, and the barbarism that reigned at the bar. Fortunately for him, however, the celebrated Paul de Foix then filled the office of counsellor to the parliament. The merit of D'Ossat could not escape the notice of a magistrate who cherished so strong a passion for letters. De Foix, notwithstanding his enthusiasm for Aristotle, and his favour for Charpentier, sought out the modest advocate, admitted him to the learned society which met at his house, and having seen cause to esteem him more and more in proportion as he became acquainted with him, procured for D'Ossat the situation of counsellor to the presidial, or local court, of Melun; an office which appears to have imposed on him little or no duty, since he continued to hold it as late as the year 1588. D'Ossat having in this way become necessary to his patron, accompanied him into Italy in the year 1574. A political mission of pure etiquette had been confided to De Foix, and he accordingly considered his journey merely as an opportunity thrown in his way of adding to his literary enjoyments. Whilst he travelled on horseback, D'Ossat explained to him Plato, whilst De Thou read the *Paratitla* of Cujas; and all the three, like worthy friends of Montaigne, sometimes discoursed together on the peripatetic philosophy. The orthodoxy of De Foix having been called in question by the pope, and his holiness having ordered "an information" on the conduct which he had pursued in the parliament, D'Ossat composed an apologetical memoir in behalf of his friend. But this defence produced no other result than making its author advantageously known. D'Ossat.

De Foix withdrew from Rome, in order to allow the proceeding which had been commenced against him to fall asleep. D'Ossat, however, remained; and it was probably during this interval that he took holy orders. In 1581, De Foix returned to Rome as ambassador of Henry III., and chose D'Ossat as his secretary. This choice was, in every respect, fortunate; and so completely did the secretary enter into the views of his principal as to the manner of conducting business, that the resemblance observable in the style of their despatches has induced an erroneous belief that these were all prepared by D'Ossat. After the death of De Foix, D'Ossat was employed in the same capacity by Cardinal Hippolyte d'Este, official protector of the church of France, whose entire confidence he had gained; and he acquired a still greater ascendency over Cardinal de Joyeuse, who succeeded Cardinal d'Este. After the disgrace of Villeroi, Henry III. offered the place of that minister to D'Ossat; but he refused to succeed a man who had strong claims on his gratitude. Besides, he foresaw that, in this elevated post, it would be impossible for him to make head against the intrigues of the Guises; and he loved his country too well to render himself subservient to their ambition. His experience prevented him from being seduced, like so many others, by the pretexts of the League; he maintained a courageous fidelity to his sovereign; and he wrote, in the name of Cardinal de Joyeuse, a letter approving of the murder of the Guises. Joyeuse afterwards allowed himself to be drawn into the ranks of the Leaguers; but he repaired his error by a noble devotion, which no subsequent act belied, to Henry IV. D'Ossat being charged by the queen-dowager, the widow of Henry III., to solicit the celebration of the obsequies of that unfortunate prince, vainly endeavoured, during several years, to overcome the resistance of the pope, who refused his assent to a ceremony which had been consecrated by usage. Whilst he was thus interceding for the memory of Henry III., De Thou dedicated to him a poem he had written on the death of that royal victim. D'Ossat, though without any public character, and without orders from the French ministry, zealously interposed to effect the reconciliation of Henry IV. with the holy see; and this prince being informed of his spontaneous exertions, as well as of his capacity, wrote to request him to put himself in communication, and act in concert, with the Duke of Nevers, who was then on his way to Rome, provided with full powers. The duke, however, despising an auxiliary calculated to prove the more useful as he was less conspicuous, undertook to conduct the negotiation alone, and completely failed. Nevertheless, Clement VIII. was exceedingly desirous that Henry should be solemnly admitted into the communion of the Catholic Church; but he wished, at the same time, to keep terms with Spain, and to obtain conditions advantageous to the holy see. D'Ossat.

Accordingly, he acted with an "innocent duplicity," which completely deceived the Spaniards. One of them, who held the office of chamberlain to the pope, having published a pamphlet in order to prove that a relapsed heretic could neither be absolved nor recognised as king, D'Ossat wrote a triumphant reply. Clement, however, although he approved of the substance of this production, required that it should only be circulated privately. D'Ossat entertained no doubt whatever as to the real intentions of the pope; but in the negotiation, with which he was

D'Ossat. at length exclusively intrusted, he had constantly to guard against the captious and formalist character of the court of Rome. When he had smoothed all obstacles, Duperron was sent to Rome to join him in receiving the stipulated absolution in name of the king. The first condition which the pope wished to impose on the royal commissioners, was to deposit the crown of France at the feet of the pontifical throne. But the representatives of Henry declared firmly that they would never consent to any proposition inconsistent with the independence of the royal authority; nor did they show themselves less decidedly opposed to every clause which had a tendency to compromise anew the tranquillity of the state, or excite alarm amongst the Huguenots. The Spanish faction murmured at not being able to prevent an absolution, which conciliated to Henry the opinion of a great number of his subjects. But their discontent was unavailing. Everything had been satisfactorily arranged, and Duperron was appointed to the bishopric of Evreux; whilst D'Ossat, who had brought about this happy result, received as his recompense the title of councillor of state, and the bishopric of Rennes.

During the remainder of his life he actively co-operated in all the diplomatic affairs which were conducted in Italy. By his means the connection which had subsisted nearly thirty years between Margaret of Valois and Henry IV. was dissolved. The dispensation granted by the pope, to validate the union of Catherine of Bourbon and the Duke de Bar, was also his work. He took part in the negotiation concerning the restitution of the marquisate of Saluces; observed the astute conduct of the Duke of Savoy; induced the Grand Duke of Tuscany to evacuate the forts which he occupied in the isles of If and Pomègue near Marseilles; proved, in a memoir which he distributed to the sacred college, that the peace recently concluded at Vervins was more necessary to Spain than to France; and was chosen to announce that peace to the senate of Venice. In satisfying Clement VIII. respecting the delay of publication experienced by the Council of Trent, the guarantees which the edict of Nantes granted to the Protestants, and the rigorous measures ordained against the Jesuits, D'Ossat displayed all the resources of an insinuating mind, and dissipated the clouds formed by the Spanish influence at the court of Rome. His experience appears to have been only once at fault, in a case where he took counsel of his affections rather than of his judgment. We allude to the assent which he gave to a project of the pope for placing upon the throne of England the Duke or Cardinal of Parma, to the prejudice of the son of Mary Stuart.

D'Ossat, by his simple and modest character, no less than by his prudence, his private virtues, and his talents, had procured for himself many friends, and reached the highest consideration he could attain in the face of the double obstacle of poverty and obscurity of birth, when, in the year 1599, he received a cardinal's hat, which was conferred on him at the earnest solicitation of the king. The following year he was appointed to the bishopric of Baïeux, which, however, he almost immediately found means to resign with advantage. Nevertheless, his last years were embittered by vexation, and saddened by disappointment. To support his dignity, he had only two benefices, the revenues of which were in part seized on by the neighbouring gentlemen. The king had granted him a pension sufficient for a man accustomed to limit his personal wants; but it was not regularly paid. Sully, who hated, in the person of D'Ossat, the protégé of Villeroi, hesitated not, first to suspend, and then altogether to discontinue, the annual prestation to which the bounty of his sovereign had given him a title; and the cardinal would have been exposed to all the pangs of shame and misery, if the heirs of Hippolyte d'Este had not paid to him a legacy of L.500, which had been exigible for more than ten years. Besides, D'Ossat, who only saw the internal situation of France with the eyes of Villeroi, formed an exaggerated notion of some disorders produced by the rigorous administration of Sully; and, under this impression, wrote to the king a letter, in which he drew a dark picture of the dangers with which he believed the state to be threatened. Sully, more irritated than ever, was loud in his complaints against the cardinal; and in his *Mémoires* may be found the imputations which he laid to the charge of a man who, like himself, had devoted all his thoughts to the service of his sovereign. D'Ossat, however, had the consolation of learning that he retained the esteem of Henry IV., if he had lost the favour of his great minister. He died on the 13th of March 1604, in the sixty-eighth year of his age; and as he had no known relations, he divided his little property between his two secretaries and the poor.

Madame d'Arconville published a prolix Life of Cardinal d'Ossat, Paris, 1771, in two vols. 8vo, in which she inserted a translation of a remarkable memoir on the effects of the League, composed in Italian by D'Ossat, and containing an able exposition of the character of the policy pursued by the Guises, with the consequences which might be expected to result from it. The Letters published under the name of Cardinal Joyeuse may also be regarded as the productions of D'Ossat; but it is to the collection of his own Letters addressed to Villeroi that he is chiefly indebted for his classical reputation in diplomacy. Chesterfield recommended them to his son as the work best calculated to give him an insight into the conduct of affairs; and Wicquefort appears to have had them continually in view in his treatise entitled *L'Ambassadeur*. The language of D'Ossat is natural and full of sincerity; his statements are marked by a grave and concise simplicity; he is almost never betrayed into any false step or unguarded expression; and he interests us equally by his modesty and his loyalty. Now, when the court of Rome is no longer the centre of negotiations, and the ideas of men have taken another course, his diplomatic correspondence has necessarily lost much of its importance; but with reference to the history of the time to which it refers, it must ever be consulted with advantage. As the collection of his Letters does not commence until the month of April 1593, it thus leaves a gap in his political life from the year 1589 until the period in question. The first edition was published at Paris in 1624, folio, by the brothers Dupuy; but it has been much surpassed by that of Amelot de la Houssaye, which appeared at the same place in 1697, in two vols. with notes, and which was reprinted with additional notes at Amsterdam, 1707, 1714, and 1732, in five vols. 12mo. This work was translated into Italian by Jerome Canini, and published at Venice, 1629, in 4to. (A.)

Ossero ‖ Ossian. OSSERO, a town of the island of Cherso, in the Adriatic, within the Austrian province of Trieste. It stands on the western side of the island, on a promontory, and is the see of a bishop, but with only 360 houses and 1540 inhabitants. It is also the name of an island separated from Cherso by a narrow channel which is not passable by vessels. It is well cultivated, and very productive of wine. It contains two townships or communes, with 1600 houses and 7200 inhabitants.

OSSIAN, the son of Fingal, a celebrated Celtic bard, who is commonly supposed to have flourished about the end of the second or the beginning of the third century.

Several incidents in the poems ascribed to him are conceived to point out this as the era of the poet; particularly the engagement of Fingal with *Caracul*, "the son of the king of the world," who, according to Macpherson and Whitaker, is the same with the son of Severus, the *Caracalla* of Roman history. Fingal, who commanded the Ca-

Ossian. ledonians at that memorable juncture, is said to have eluded the power of Severus, and gained a signal victory on the banks of the Carron, in which Caracul fled from his arms "along the fields of his pride." As Gibbon observes, however, "Something of a doubtful mist still hangs over these Highland traditions, nor can it be entirely dispelled by the most ingenious researches of modern criticism; but if we could with safety indulge the pleasing supposition that Fingal lived, and that Ossian sung, the striking contrast of the situation and manners of the contending nations might amuse a philosophic mind. The parallel," he adds, "would be little to the advantage of the more civilized people, if we compared the unrelenting revenge of Severus with the generous clemency of Fingal; the timid and brutal cruelty of Caracalla with the bravery, the tenderness, the elegant genius of Ossian; the mercenary chiefs who, from motives of fear or interest, served under the imperial standard, with the free-born warriors who started to arms at the voice of the king of Morven: if, in a word, we contemplated the untutored Caledonians, glowing with the warm virtues of nature, and the degenerate Romans, polluted with the mean vices of wealth and slavery."

Speculations like these, however, though they may amuse by their novelty, or surprise by a striking contrast of situation and of manners, can have no real value in themselves, if they rest merely on a "pleasing supposition," unsupported by evidence. "That Fingal lived, and that Ossian sung," can only be believed upon the assumption that the poems ascribed to the son of the Caledonian hero are authentic productions; and, until this be established, it is obviously vain to attempt to deduce from them any inference as to the existence of the one, the era of the other, or the circumstances and manners of the times when they are said to have flourished. The primary question therefore is, Are the poems attributed to Ossian, more especially those given to the world by Macpherson, the genuine productions of a Celtic bard of the third century; or are they, on the other hand, a forgery, palmed upon the world by an individual who attempted to give currency to his own compositions under the mask and pretence of a high antiquity?

"The appearance of the poems of Ossian," says the Abbate Cesarotti, "was a phenomenon so unexpected and extraordinary, that it is not surprising they should have excited doubts and astonishment, even during the period of enthusiasm itself, in a country scarcely known to history—wild, savage, and covered with mists; in a state of society the most rude, miserable, and barbarous, without commerce, without learning, without writing, and without arts; how could there arise so transcendent a genius, who should at length come to dispute the palm with the most celebrated poets of the most polished nations, nay, even with those who for so many ages were regarded as models of the art? This novelty was too much at variance with all received opinions to be believed without question, or admitted without controversy. Was there truly an Ossian? Was he really the author of the poems which have been published under his name? Can this be a spurious work? But when? How? By whom? These are the questions which have divided England and civilized Europe respecting this surprising phenomenon. These are the doubts which have been raised by learned men and critics; doubts which, though much weakened, have not yet been entirely removed from the minds of many persons. Whatever opinion be adopted, it is certain that various embarrassing difficulties present themselves, and that the most strenuous advocates on both sides cannot fail to waver in their conclusions."[1] Ossian.

The ingenious Italian translator having here suggested the questions which it is most material to resolve, before any conclusion can be safely deduced from the contents of the poems themselves, we shall endeavour to furnish our readers with the means of judging for themselves respecting the whole matter in controversy; first, by submitting a short historical account of the manner in which the poems ascribed to Ossian are said to have been originally collected, translated, and published, by Macpherson; secondly, by exhibiting a summary of the arguments which have been employed to disprove the authenticity of these poems; thirdly, by stating the results of the elaborate inquiry into the nature and authenticity of the poems of Ossian, instituted by the Highland Society of Scotland, and conducted by a Committee of that body, under the auspices of its chairman, Mr Henry Mackenzie, by whom the Report was drawn up; and, lastly, by subjoining some particulars respecting the other collectors of Celtic poetry, whose proceedings form a curious sequel to those of Mr James Macpherson. It is only by a clear and comprehensive statement of the whole case, that a rational judgment can be formed respecting the various matters in dispute; nor is it possible otherwise to enable the reader to decide for himself, whether the doubts raised by learned men and critics have been removed, or even in any material degree obviated.

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[1] L'apparizione delle poesie di Ossian era un fenomeno così impensato e straordinario, che non è da stupirsi se destò nel tempo stesso entusiasmo, sorpresa, e dubbi. In un paese appeno noto alla storia, alpestre, selvaggio, ingombro, e quasi oppresso di nebbia; in uno stato di società il più rozzo, meschino, e barbaro, senza commercio, senza idee, senza scrittura, senz'arti, come potea sorgere un Genio così trascendente, che venisse a disputar la palma ai poeti più celebri delli più colte nazioni; a quegli stessi, che si riguardano da tanti secoli come i modelli dell'arte? Questa novità rovesciava troppo tutte le idee ricevute per esser accolta senza contrasto. Vi fu veramente un Ossian? fu egli realmente l'autore delle poesie, che comparvero sotto il suo nome? Sarebbe questa un' opera supposta? ma quando? come? da chi?...Ecco le questioni, che per lungo tempo divisero l'Inghilterra, et l'Europa colta sopra questo sorprendente fenomeno. Ecco i dubbi, chè insorsero nei letterati, e ne'critici; dubbi che quantunque indeboliti di molto, non sono però cessati interamente in tutti gli spiriti. Qualunque opinione si adotti, è certo, che l'una e l'altra presentano varie difficoltà imbarazzanti, e che possono far vacillare i più fermi sostenitori dei due partiti." (*Ragionamento Storico-Critico intorno le Controversie sull' Autenticità dei Poemi di Ossian nell' Opere dell' Abbate Cesarotti*, vol. ii. p. 49, Firenze, 1807, in 12mo.)

An English translation of Cesarotti's Historical and Critical Dissertation was published by Dr John M'Arthur (London, 1806, in 8vo), "one of the Committee of the Highland Society of London, appointed to superintend the publication of Ossian in the original Gaelic." But, for the sake of the Celtic bard, it is to be hoped that this gentleman's knowledge of Italian cannot be taken as the measure of his acquaintance with Gaelic. We have been at the pains to compare his translation with the original, and the result has been to satisfy us that he was not only incapacitated, by ignorance of the language, for translating any Italian work correctly; but that he has, in several parts of the Historical and Critical Dissertation, been guilty of *material suppressions*. Examples of both occur in his translation of the passage above quoted. 1. The words of the original, "in uno stato di società il più rozzo, meschino, e barbaro, senza commercio, senza idee, *senza scrittura*, senz'arti," he renders, "in a state of society the most unpolished, wretched, and barbarous;" thus *suppressing* the material words, "senza scrittura," *without writing*, containing an important admission on the part of the Italian translator of Ossian. 2. His knowledge of the original may be judged of from his translation of the following sentence: "Ecco le questioni, che per lungo tempo divisero l'Inghilterra, e l'Europa colta sopra questo sorprendente fenomeno," which he renders thus: "These are questions that for a length of time have *agitated* and divided *public opinion in* England, *while* Europe *regarded with veneration* this surprising phenomenon." This is either ignorance, or something still worse. Cesarotti says nothing about "Europe *regarding with veneration*," &c.: what he states is, that the questions he had indicated long divided England, *and* civilized Europe, respecting the unexpected and extraordinary appearance of the poems of Ossian. Numerous instances of a similar and still more striking kind might easily be added.

Ossian.

I. The first person who seems to have conceived the idea of collecting and translating some of the traditional poems floating in the Highlands, was a young man named Jerome Stone, formerly a schoolmaster at Dunkeld. In 1756, he published, in the Scots Magazine, a translation in verse of *Bas Fhroich*, or the death of Fraoch, under the title of Albin and Mey; and this specimen he accompanied with a short letter addressed to the editor, indicating his opinion of the poetical merits of the various pieces in his possession. Stone did not think of giving to the public the original of his translation; but Mr Mackenzie, having procured it from Mr Chalmers of London, into whose hands it had accidentally fallen, has inserted it in the appendix to the Report of the Committee of the Highland Society, with Stone's version and a literal translation subjoined. This poem, according to Dr Graham, approaches nearer to the style of the Gaelic fragments of Ossian than any thing he had yet met with.[1] About the same time Mr Pope, minister of Reay, in Caithness, had thoughts of making a collection of the old Highland poems ascribed to Ossian, in concert with a gentleman then living on Lord Reay's estate; but the death of the latter, upon whose assistance he had mainly depended, put an end to the scheme.[2]

The next, and by far the most celebrated, collector of Gaelic poetry, was Mr James Macpherson, whose translations first attracted notice to the supposed productions of the Celtic muse, and whose proceedings in connection with these gave rise to the controversy which so long divided the literary world. The circumstances which originally led to the employment of this gentleman as a collector and translator of Gaelic poetry, have been fully stated by Mr Mackenzie, in the Report of the Committee of the Highland Society.

Mr Home, author of Douglas, happening to be at Moffat, a watering-place in Dumfriesshire, in the summer of 1759, met there with Macpherson, whom he found officiating as tutor to Mr Graham, younger of Balgowan, whose father's family was then residing at that place. In the course of his inquiries about the manners and customs of the Highlanders, Mr Home learned from Macpherson, that one of their favourite amusements consisted in listening to the compositions of their ancient bards, which were described as highly pathetic and imaginative; and some fragments of these traditional poems, which, at Mr Home's desire, Macpherson translated from memory, struck him as exceedingly beautiful. Mr Home communicated these pieces to his friends, whose opinion proved as favourable as his own; and, under this impression, they prevailed on Macpherson to publish them in a small volume at Edinburgh, at the same time undertaking to superintend the publication, and also to defray the expense. To this volume Dr Blair wrote an introduction; and, on its appearance, it attracted "universal attention." The literary circle of Edinburgh, consisting of David Hume, Dr Robertson, Dr Blair, Dr Carlyle, Mr Home, and others, felt much interested in the discovery of what seemed to be a new mine of poetical wealth; and a subscription was accordingly entered into to enable Macpherson to make a tour through the Highlands for the purpose of collecting larger and more complete poems, which he represented as still existing there, and of which some of the pieces already published were described by him as only detached and disconnected fragments. He particularly mentioned a poem in an epic form, and of considerable length, on the subject of the wars of Fion or Fingal, which he thought might be recovered entire. Mean while, that is, about 1758, he published, in his own name, a poem, entitled *The Highlander*, which appears to have sunk into oblivion immediately after its publication; but the remembrance of this production was revived by Mr Laing, in the controversy which subsequently arose respecting the authenticity of the poems ascribed to Ossian; and it is not a little remarkable that the style and imagery of the poem called Fingal occur in almost every page of The Highlander.

Ossian.

Under the patronage of the eminent individuals already mentioned, Macpherson performed his literary tour in 1766; transmitting from time to time accounts of his progress, and of the various poems which, as he said, he had succeeded in collecting. The districts through which he travelled were chiefly the north-western parts of Inverness-shire, the Isle of Skye, and some of the adjoining islands; places which, from their remoteness, and the state of manners that then existed in them, were thought the most likely to afford, in a pure and genuine state, those traditionary tales and poems in the recital of which the Highlanders were represented as taking so much delight. On his return from the north, Macpherson passed some time with an early acquaintance of his own, Mr Gallie, then a missionary in Badenoch; and availed himself of the assistance of this gentleman, as well as of that of Mr Macpherson of Strathmashie, in collating the different copies of the poems which he had collected, in translating difficult passages, and in determining the meaning of obsolete words.[3] He then proceeded to Edinburgh, where he communicated to his patrons the result of his expedition, and in 1762 published *Fingal*, an epic poem in six books, with some other detached pieces of a similar kind. In an advertisement prefixed to Fingal, he states, that "some men of genius had advised him to print the originals by subscription, rather than deposit them in a public library;" and, in the preliminary dissertation, he says that "his translation is literal, and that as he claims no merit on account of his version, he wishes that the imperfect semblance which he draws may not prejudice the world against an original which contains what is beautiful in simplicity, or grand in the sublime." In the year 1765, he published another epic poem, entitled *Temora*, to the seventh book of which he annexed the original Gaelic; but of all the rest he published only translations. At his death, however, he left a sum of money for defraying the expense of publishing the originals of the whole, with directions to his executors for carrying that purpose into effect. But, from whatever cause, this publication has not yet appeared, and it is more than probable that it never will.[4]

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[1] Essay on the Authenticity of Ossian's Poems, p. 208, et seq. [2] Appendix to the Report on Ossian, No. 3.

[3] It is alleged that Macpherson, when he undertook his journey to the Highlands, was but an indifferent proficient in the Gaelic language. An instance of this, to which much importance seems to be attached, is recorded in the Appendix to the Committee's Report (p. 95); and a Highland gentleman who met him in London in 1762 also describes him as being "very imperfectly acquainted with the Gaelic language." The instance mentioned in the Report, however, amounts only to a verbal blunder in conversation, and is so very trifling, that we are surprised to find it gravely adduced as a proof of Macpherson's ignorance of Gaelic; whilst as to the opinion expressed by the Highland gentleman who met Macpherson in London, the measure of its value must be the competency of that individual to form a correct judgment, a subject on which we have no information. The object of impeaching Macpherson's knowledge of Gaelic is to render it improbable that he could have fabricated the originals of the poems which he professed to have translated. But it is forgotten that Gaelic was his mother tongue; and that, though his knowledge of that language might not be great, he could command the assistance of others who were more skilful than himself.

[4] All the information that the Committee of the Highland Society could collect on this subject is contained in the following passage of their Report (p. 79, et seq.):—"A source of information to which your Committee early applied was the executors of Mr Macpherson, of whom they requested to know if he had left behind him any of those MSS., particularly those ancient books which the Committee understood he possessed. Mr John Mackenzie, of the Temple, London, whom Mr Macpherson had left sole trustee

Ossian. The success of Macpherson's translation of the poems ascribed to Ossian was very great, and the sensation produced by them in the literary world altogether unprecedented. Mr David Hume justly observed of them, that they were, if genuine, one of the greatest curiosities in all respects that ever had been discovered in the commonwealth of letters. But at an early period after the success of these translations had been ascertained, suspicions of fabrication were excited, chiefly by the conduct and language of the translator himself; who not only refused to satisfy reasonable doubts, but allowed expressions to escape him which were understood to imply an intention on his part of appropriating to himself the poems which, in the first instance, he had professed to have only translated. This clearly appears from the correspondence between Dr Blair and Mr Hume, about a year after the publication of Fingal with the detached pieces that accompanied it. When Dr Blair wrote his Dissertation in 1763, he proposed to annex it to certain documents in support of the authenticity of the poems ascribed to Ossian; and, with this view, he applied to Mr Hume for his opinion as to the kind of evidence which he should endeavour to obtain on the subject. In answer to this request, Mr Hume, who was then in London, wrote two letters, which have been fortunately preserved; containing a clear exposition of his own views, as well as of the state of public opinion at that time; and placing in a striking light the extraordinary conduct pursued by Macpherson, when called upon to afford information, or to assist in removing the doubts which he had himself been mainly instrumental in raising. The first of these letters is dated the 19th of September 1763, and is in the following terms:—

"I live in a place where I have the pleasure of frequently hearing justice done to your Dissertation, but never heard it mentioned in a company where some person or other did not express his doubts in regard to the authenticity of the poems which are its subject; and I often hear them totally rejected with disdain and indignation, as a palpable and most impudent forgery. This opinion has indeed become very prevalent among the men of letters in London; and I can foresee that, in a few years, the poems, if they continue to stand on their present footing, will be thrown aside, and will fall into final oblivion. It is in vain to say that their beauty will support them independent of their authenticity: No; that beauty is not so much to the general taste as to insure you of this event; and if people be once disgusted with the idea of a forgery, they are thence apt to entertain a more disadvantageous notion of the excellency of the production itself. The absurd pride and caprice of Macpherson himself, who scorns, as he pretends, to satisfy any body that doubts his veracity, has tended much to confirm this general scepticism; and I must own, for my own part, that though I have had many particular reasons to believe these poems genuine, more than it is possible for any Englishman of letters to have, *yet I am not entirely without my scruples on that head.* You think that the *internal proofs* in favour of the poems are very convincing: So they are; but there are also *internal reasons* against them, particularly from the manners, notwithstanding all the art with which you have endeavoured to throw a varnish on that circumstance; and the preservation of such long and such connected poems, *by oral tradition alone*, during a course of fourteen centuries, is so much out of the ordinary course of human affairs, that it requires the strongest reasons to make us believe it. My present purpose therefore is, to apply to you in the name of all the men of letters of this, and, I may say, of all other countries, to establish this capital point, and to give us proofs that these poems are, I do not say so ancient as the age of Severus, but that they were not forged within these five years by James Macpherson. These proofs must not be *arguments*, but *testimonies:* People's ears are fortified against the former; the latter may yet find their way before the poems are consigned to total oblivion. Now the testimonies may, in my opinion, be of two kinds. Macpherson pretends that there is an ancient manuscript of part of Fingal in the family, I think, of Clanronald. Get that fact ascertained by more than one person of credit; let these persons be acquainted with the Gaelic; let them compare the original and the translation; and let them testify the fidelity of the latter.

"But the chief point in which it will be necessary for you to exert yourself, will be to get positive testimony from many different hands that such poems are vulgarly recited in the Highlands, and have there long been the entertainment of the people. This testimony must be as particular as it is positive. It will not be sufficient that a Highland gentleman or clergyman say or write to you that he has heard such poems; nobody questions that there are traditional poems in that part of the country, where the names of Ossian and Fingal, and Oscar and Gaul, are mentioned in every stanza. The only doubt is, whether these poems have any farther resemblance to the poems published by Macpherson. I was told by Burke, a very ingenious Irish gentleman, the author of a tract on the Sublime and Beautiful, that, on the first publication of Macpherson's book, all the Irish cried out, *We know all these poems; we have always heard them from our infancy:* but when he asked more particular questions, he could never learn that any one had ever heard or could repeat the original of any one paragraph of the pretended translation. This generality, then, must be carefully guarded against, as being of no authority.

"Your connections among your brethren of the clergy may here be of great use to you. You may easily learn the names of all the ministers of that country who understand the language of it. You may write to them, expressing the doubts that have arisen, and desiring them to send for such of the bards as remain, and make them rehearse their ancient poems. Let the clergymen then leave the translation in their hands, and let them write back to you, and inform you that they heard such a one (naming him), living in such a place, rehearse the original of such a passage, from such a page to such a page of the English translation, which appeared exact and faithful. If you give to the public a sufficient number of such testimonies, you may prevail; but I venture to foretell to you that nothing less will serve the purpose, nothing less will so much as command the attention of the public.

"Becket tells me that he is to give a new edition of your Dissertation, accompanied with some remarks on *Temora.* Here is a favourable opportunity for you to execute this purpose. You have a just and laudable zeal for the credit of these poems. They are, if genuine, one of the greatest curiosities in all respects that ever was discovered in the commonwealth of letters; and the child is, in a manner, become yours by adoption, as Macpherson

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for the purpose of publishing the originals of Ossian, informed the Committee, that, after a strict search, *no such books could be found*, and that the manuscripts left by Mr Macpherson *were not ancient, but in the handwriting of himself, or of others whom he had employed to take down the poetry from the recitation of Highlanders*, or to copy it from the manuscripts with which he had been furnished. Of the books of which the Committee had so often heard, *only one* was recovered," which is described as being "of very little value;" and it is added, that "whether its insignificance, or any other circumstance, contributed to its preservation, the Committee will not venture to decide."

Ossian. had totally abandoned all care of it. These motives call upon you to exert yourself, and I think it were suitable to your candour, and most satisfactory also to the reader, *to publish all the answers to all the letters you write, even though some of these letters should make somewhat against your opinion in this affair.* We shall always be the more assured that no arguments are strained beyond their proper force, and no contrary arguments suppressed, where such an entire communication is made to us. Becket joins me heartily in this application, and he owns to me that the believers in the authenticity of the poems diminish every day among the men of sense and reflection. Nothing less than what I propose will throw the balance on the other side."

The next letter of Mr Hume to Dr Blair is dated at London, the 6th of October 1763, less than a month after the date of the preceding, and contains the following passage in reference to this subject:—" I am very glad you have undertaken the task I used the freedom to recommend to you. Nothing less than what you propose will serve the purpose. You need expect no assistance from Macpherson, who flew into a passion when I told him of the letter I had wrote to you. But you must not mind so strange and heteroclite a mortal, than whom I have scarce ever known a man more perverse and unamiable. He will probably depart for Florida with Governor Johnstone, and I would advise him to travel among the Chickisaws or Cherokees, in order to tame him and civilize him."[1]

The line of conduct here traced out for Dr Blair by his illustrious friend is not very dissimilar to that which, without the advantage of knowing Mr Hume's advice, the Committee of the Highland Society afterwards followed, in preparing materials for the Report, the substance of which we shall have occasion to lay before our readers.[2] It is evident, however, that, from the very first, suspicions of fabrication had been excited, which all the zeal and ability of Dr Blair had been insufficient to remove; that " the internal proofs" in favour of these poems, which the doctor thought so convincing, had nevertheless failed to produce conviction; and that the strange conduct of Macpherson himself, in not only refusing to assist in satisfying those who entertained rational doubts, but in positively resisting all inquiry or investigation, had tended much to confirm this general scepticism.

The proceedings of this person, indeed, are scarcely reconcileable with the supposition that he acted fairly and uprightly in the matter. At first, he represented his translation as literal, and in his dissertation, published in 1762, he says, that " the translator, as he claims no merit from his version, wishes that the imperfect semblance which he draws may not prejudice the world against an original which contains what is beautiful in simplicity, or grand in the sublime." But, afterwards, when the success of his translation had been ascertained, he began to hold very different language; and, notwithstanding the strong and pointed assertions of their originality which he had advanced in his prefaces and dissertations prefixed to the earlier editions of these poems, he allowed expressions to escape him which unequivocally indicated an intention of appropriating the *authorship* to himself. In one passage he says that those who have doubted his veracity have paid a compliment to his genius, and that *even* were the allegation *true*, his self-denial might have atoned for his fault. " I can assure my antagonists," he adds, " *that I should not translate what I could not imitate;*" and again, in a similar vein, he says that " the translator who cannot *equal* his original is incapable of expressing its beauties." As his confidence increased he became still more explicit, and, in one of his prefaces, we meet with the following passage: " Without increasing his genius, the AUTHOR may have improved his language, in the eleven years that the poems have been before the public. Errors in diction may have been committed at twenty-four, which the experience of a riper age may remove, and *some exuberances of imagery may be restrained with advantage*, by a degree of judgment acquired in the progress of time. *In a convenient indifference to literary fame, the* AUTHOR *hears praise without being elevated, and ribaldry without being depressed.* The writer's first intention was to have published in verse; and as *the making of poetry* may be learned by industry, he had served his apprenticeship, though in secret, to the Muses." This language, it will be admitted, involves an avowed claim to the *authorship* of the poems, of which, at first, he professed to have been only the literal translator, and it has generally been understood by the public as such. It is, in fact, too explicit to be mistaken, and, as far as Macpherson is concerned, leaves no doubt whatever that he wished to be considered as the author, not the translator, of the poems attributed to Ossian. Ossian.

His conduct in regard to the originals, as he called them, was likewise calculated to excite strong suspicions. When he gave these poems to the world as translations, he seems to have imagined that they would be at once received as such, on his authority, without question and without challenge. Finding himself mistaken, however, and being apparently in no condition to satisfy the demand for the publication of the originals which simultaneously proceeded from various quarters, he assumed, and ever afterwards maintained, that tone of defiance to which Mr Hume has so pointedly alluded in the letters above cited, hoping thus to evade the production of evidence which he had it not in his power to furnish. It is more than insinuated in the Report of the Highland Society's Committee, that Macpherson destroyed several ancient manuscripts which had once been in his possession; with the view, as it would seem, of preventing his claim of authorship being disproved after his death. But, in the first place, nothing seems to be known as to the date or the contents of the manuscripts referred to; secondly, those actually left by Macpherson were not ancient, but all in the handwriting of himself, or of others whom he had employed to take down poetry from the recitation of the Highlanders, and consequently their authenticity was as open to challenge as the pretended translations he had published; thirdly, the advertisement said to have been published by Becket, the bookseller in the Strand, on the occasion of the controversy between Dr Johnson and Mr Macpherson, certifying that the originals of Ossian had lain at his shop for subscription during a whole year, proves nothing, inasmuch as Becket was certainly no judge of the genuineness or authenticity of those manuscripts; fourthly, upon various pretexts Macpherson constantly evaded giving the

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[1] See Report, &c. p. 4, *et seq.*; and Laing's Hist. of Scotland, vol. iv. p. 494.

[2] Dr Blair himself did not comply with the admonition of his friend, " to publish *all* the answers to *all* the letters he should write, even though some of them should make against his own opinion in this affair." On the contrary, in the appendix to the second edition of his Dissertation, " instead of printing the testimonies entire as he received them, he published an imperfect abstract, in which the evidence was unavoidably corrected and improved; softened when extravagant, and tinged throughout with his own prejudices and preconceived opinions." (Laing's Hist. of Scotland, *ubi supra.*) " From the perusal of the original testimonies, which relate in fact to the Irish ballads, I do not hesitate to affirm," says the same writer, " that had they been published entire, they would have appeared as little satisfactory to the world as they did to Mr Hume, when he informed Gibbon 'that any positive evidence on the subject ought never to be regarded.'"

Ossian. public access to his manuscripts, at one time proposing to print them by subscription, and at another to deposit them in some public library; and, lastly, they have not yet been published, and probably never will, because, if they were, their authenticity would be fully as liable to challenge or dispute as the translations which Macpherson professed to have made from them. The demand made by Dr Johnson and others was in itself most reasonable; and the refusal to produce evidence, merely because men doubted in a case where there was great room for incredulity, is either a proof that none whatever existed, or an instance of perversity unexampled in the history of literary controversy.[1]

II. But if Blair, in his elaborate and rhetorical Dissertation, had done little or nothing to remove the doubts which from the first were entertained as to the authenticity of the poems ascribed to Ossian, incredulity gained still greater confidence from the formidable and systematic onset of Mr Laing. In the third volume of his History of Scotland, that gentleman, in treating of the Highlanders, had adverted to the state of society and manners represented in these poems, as existing amongst that people, about the end of the second or commencement of the third century, and had thence deduced an argument against the authenticity of productions displaying a refinement and cultivation of sentiment inconsistent with all history and experience. "The productions of the Celtic muse," said he, "would persuade us to believe that the early manners of the Highlanders displayed a civilization inconsistent with an utter ignorance of the arts of life; an uniform heroism unknown to barbarians; a gallantry which chivalry never inspired; a humanity which refinement has never equalled; and that before their advance to the shepherd state, they possessed a correct taste, a polished diction, a cultivated and sublime poetry, enriched with the choicest images of classical antiquity, and intermixed with all the sentimental affectation of the present times. Their history contains no marks of primeval refinement, unless we can persuade ourselves that their descendants, as soon as they approached observation, degenerated on emerging from the savage state, and became more barbarous in proportion as they became more civilized."

The improbability of such an inversion of the ordinary law of human society is sufficiently apparent. But Mr Laing, not content with urging this argument, which he held to be "unanswerable," annexed to the fourth volume of his history a "Dissertation on the supposed Authenticity of Ossian's Poems," in which he has reduced his numerous detections, historical and critical, under a few general heads, "and endeavoured," as he says, "to disabuse his countrymen, and to put an end, if possible, to the controversy and deception for ever." These heads are, the Roman History of Britain, the Middle Ages, Tradition, the Customs and Manners of the Times, the Real Origin of the Poems, Imitations of the ancient and modern Poets, the pretended Originals, and Macpherson's avowal of the whole impos- Ossian. ture; thus embracing the whole question in all its bearings and details. In such an article as the present, it is of course impossible to enter into a subject branching out into so many divisions; or even to attempt giving an abstract of the various arguments which have been urged by Mr Laing in attempting to disprove the authenticity of the poems ascribed to Ossian. We shall therefore content ourselves with indicating a few of the leading points, leaving those who take an interest in the controversy, or desire further information, to consult the Dissertation itself.

On the first branch of his subject, Mr Laing contends that, as the Highlanders originated from Ireland, and as their arrival from that country is established by the concurrence of every Scottish and Irish historian, whether their first migration is placed in 258 under Cairbar Riada, or postponed until 503, when they were restored by Fergus MacErth and his brother Loarn, there was not a Highlander in Scotland of the present race at the beginning of the era which is assigned to Fingal by Macpherson. He next shows, that by connecting his poems with Roman history, Macpherson has fallen into the most ridiculous mistakes. Gibbon had previously remarked the absurdity of making the Highland bard describe the son of Severus "by a nickname invented four years afterwards, scarcely used by the Romans till after the death of that emperor, and seldom employed by the most ancient historians;"[2] and the detection is as complete with respect to Carausius, who is represented as the contemporary and successor of that emperor. The most noted or classical places in Scotland are also, by a dexterous anticipation, appropriated to Ossian, as Carron, Glencoen or Cona, and Dumbarton the Alcuith of Bede. The name of Balclutha Mr Laing considers as fictitious; and in Fingal's intercourse with other nations he discovers the same minute yet conclusive anachronisms. The invasions from Lochlin, a name unknown until the ninth century, are also, according to Mr Laing, equally fabulous with the pretended exploits of Fingal against the Romans. The detections resulting from a comparison of the incidents mentioned in these poems with the history of the middle ages are not less important. They relate chiefly to Magnus, surnamed Barefoot; Cathula or Ketil, the friend of Fingal; Carrick-Thura, the palace of the king of Innistore; and the circle of Loda.

But one of the strongest points of Mr Laing's argument is that which has for its object to disprove that poems of such length could have been preserved entire, for upwards of fifteen hundred years, by means of oral tradition alone. "It is indeed strange," says Hume, in a letter to Gibbon, "that any man of sense could have imagined it possible, that above twenty thousand verses, along with numberless historical facts, could have been preserved by oral tradition, during fifty generations, by the rudest, perhaps, of all the civilized nations, the most necessitous, the most turbulent, and the most unsettled. Where a suppo-

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[1] "I suppose my opinion of the poems of Ossian," says Johnson, "is already discovered. I believe they never existed in any other form than that which we have seen. The editor or author never could show the original, nor can it be shown by any other: to revenge reasonable incredulity by refusing evidence, is a degree of insolence with which the world is not yet acquainted; and stubborn audacity is the last refuge of guilt. It would be easy to show it if he had it; but whence could it be had? It is too long to be remembered, and the language formerly had nothing written. He has doubtless inserted names that circulate in popular stories, and may have translated some wandering ballads, if any can be found; and the names and some of the images being recollected, make an inaccurate auditor imagine that he has formerly heard the whole." (*Journey to the Western Islands*, pp. 273, 274, London, 1774.) Bishop Warburton expresses a similar opinion. "Several fragments in these poems have been heard by living witnesses, sung to the harp both in the Highlands and in Ireland. My solution of the difficulty is, that on these and from these fragments the forgery has been erected." "You will say," he adds, "it is a work infinitely above one of those *tame cheaters* we call a sophist. I do not know how it is, but mimicry is a species of poetic imitation so different from the true, that we have seen excellent copies in painting from originals of great masters, by those whose own designs were all sign-post daubings. The most celebrated mimics on the stage, as Eastcourt and Foote, were the most miserable actors; and, to come a little nearer, the book written by Burke against civil society, under the name and character of Bolingbroke, is far superior to any other of his compositions." (*Extract of a Letter to Mr Mason*, dated 12th January 1762.)

[2] Gibbon's Decline and Fall of the Roman Empire, vol. i. c. 8, p. 209. Macpherson gives three several etymologies of the name *Caracalla*, being altogether unconscious of the historical anachronism in which it involved him.

Ossian. sition is so contrary to common sense, any positive evidence of it ought never to be regarded. Men run with great avidity to give their evidence in favour of what flatters their passions and their national prejudices." The consideration of the mutability of language also supplies an argument which cannot easily be obviated. This is counteracted only by letters and by the art of printing; but an unwritten language naturally diverges into different dialects, and in every age assumes a new form, although the radical structure may remain. If these poems, then, are alleged to have been preserved by oral tradition, in an obsolete diction, that is, in a dialect disused by the people, this alone is sufficient to confute their authenticity. But if it be maintained that the language has remained invariably the same since the end of the second or beginning of the third century, this is contrary to the experience of all nations, and, besides, is disproved by the difference of the Gaelic from the parent Irish, a page of which a few centuries old is confessedly unintelligible to the people of the present day. Nor has the difficulty been in any degree removed by the numerous attestations which have, at different times, been obtained. No sooner were the translations published, than the traditionary existence of the poems disappeared. When Dr Johnson visited the Western Isles, the natives had nothing to communicate that deserved attention; and his assertion that there was not a Gaelic manuscript above a century old still remains undisproved by the publication of any such document. In proof that the Highlanders were neither rude and illiterate, nor the Gaelic an unwritten language, in the time of Ossian, it has been alleged that the Druids, when expelled from Scotland, retired to Iona, where they established a college, and lived and taught unmolested till the sixth century, when they were dispossessed by St Columba. But, according to Mr Laing, there is no evidence, nothing indeed but conjecture, that the Druids ever existed in Ireland; and the fact appears to be certain, that there never was a Druid in Scotland, otherwise Tacitus, who describes the destruction of their order in England, would most probably have remarked their influence or existence under Galgacus in the Caledonian war. "The man," he adds, "who can thus create an historical fact, requires nothing but genius to fabricate an epic poem." Finally, if manuscripts be appealed to, "let a single book of Fingal in manuscript, such as translated by Macpherson, of an older date than a century, be produced and lodged in a public library, and there is an end of the dispute."

Mr Laing then proceeds to show that the contradiction is not greater between the primeval refinement ascribed to the Highlanders, and their recent barbarism, than between their real manners at the period of Fingal and those described in the poems of Ossian. He alleges that religion was avoided as a dangerous topic, which led to detection; that, from the difficulty of inventing a religious mythology, Macpherson has created a savage society of refined atheists, who believe in ghosts, but not in deities; and that, solicitous only for proper machinery, he has rendered the Highlanders a race of unparalleled infidels, who believed in no gods but the ghosts of their fathers. And the same difficulty, he adds, occurred in the adaptation of circumstances, peculiar customs, or rites, to the supposed state of society; points on which Macpherson has laid himself open to suspicion or detection. Mr Laing next traces the origin of the poems ascribed to Ossian, which he ascribed to the failure of Macpherson's avowed poem, entitled The Highlander, published at Edinburgh in 1758, four years before the appearance of Fingal, and a desire on the part of Macpherson to insure a more favourable reception to his subsequent productions, by assigning to them a remote antiquity.[1] He shows, that when The Highlander is examined, its plot exhibits the very outlines of Fingal; that the inferiority of The Highlander to Fingal affords no presumption whatsoever that the latter is authentic; and that the Fragments of Gaelic Poetry published at Edinburgh in 1760, were produced when his taste and style had been considerably improved. But the most copious and curious source of detection is, according to Mr Laing, the constant imitation of the classics, the Scriptures, and such temporary publications as were then in vogue. The details on this part of the subject admit not of any condensation, and the reader is consequently referred to the Dissertation itself. Some of the supposed imitations are perhaps a little overstrained, and others not very obvious or striking; but the number that is liable to neither objection is so great, and in many cases so apparent, as to be altogether destructive of the notion that Macpherson translated from originals which had been composed by a Celtic bard, who flourished fifteen centuries before the time when his pretended compositions were given to the public. As to the specimens of the original produced by Macpherson, Mr Laing contends that they were translated into Gaelic from the *English original* by the translator himself; and, in particular, that the original Gaelic of Malvina's Dream was produced by the translator at the request of Lord Kames. Lastly, he has shown that, from the very beginning, Macpherson avowed the deceit, and that he ended, as we have already seen, by expressly vindicating and appropriating to himself the poems which he had at first attributed to Ossian. Ossian.

Dr Graham's Essay on the Authenticity of the Poems of Ossian professes to be an answer to Mr Laing's masterly Dissertation on the same subject. But in reality it is only a piece of captious controversial writing, deficient in critical ability, displaying neither originality, acuteness, nor research, and as devoid of candour and fairness[2] as it is

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[1] What says Mr Macpherson himself in his preface to Fingal? "Poetry, like virtue, receives its reward *after death*. The fame which men pursued in vain, when living, is often bestowed upon them when they are not sensible of it. This neglect of *living authors* is not altogether to be attributed to that reluctance which men show *in praising and rewarding genius*. It often appears that the man *who writes* differs from the *same man* in common life. His foibles, however, are obliterated by death, and his better part, *his writings*, remain: his character is formed from them; and he that was *no extraordinary man* in his own time, becomes the *wonder of succeeding ages*. From this source proceeds our veneration for the dead. Their virtues remain, but the vices which were once blended with their virtues have died with themselves. *This consideration might induce a man, diffident of his abilities, to ascribe his own compositions to a person whose remote antiquity, and whose situation when alive, might well answer for faults which would be inexcusable in a writer of this age.*"

[2] Dr Graham, in the Introduction to his Essay, has taken occasion to remark, "that though the Committee of the Highland Society of Scotland has, *very properly, considered it as* BENEATH ITS DIGNITY TO STOOP *to the refutation of the arguments of Mr Laing*, it may not be improper for one who has little to lose, and who may have the good fortune to gain some advantage in the discussion, to enter the lists even with this powerful antagonist." It would have been more creditable to Dr Graham, however, if he had not prefaced his entry into the lists, as he calls it, by a most unpardonable misrepresentation. In the Report of the Committee, there is not one word from which it can, by any violence of construction, be inferred that they were guilty of the ridiculous folly and presumption here ascribed to them. They very properly "wished sedulously to avoid anything like controversy, desirous rather of procuring *evidence* and *information*, than of *drawing inferences* from them;" and, so far from their Report embodying any expression which could justify the strange assertion that they "considered it as beneath their dignity to *stoop* to the refutation of Mr Laing's arguments," which was no part of the plan upon which they proceeded, it contains abundant proofs of the respect and deference which they showed for the views and opinions of that distinguished person. Compare with this disingenuous allegation, the honest valedictory appeal of the ac-

Ossian. of ingenuity or talent. At the outset, Dr Graham seems disposed to throw James Macpherson overboard. "I speak only of the poems," says he; "of Macpherson's dreams I make no account." But, unfortunately, the one can never be separated from the other. The question is not as to the existence of detached poems, songs, or "wandering ballads," which nobody has disputed; but whether it is possible now to produce the originals of Fingal, Temora, and other poems, of which Mr Macpherson has given what he calls translations, and at the same time to establish the authenticity of these originals. Until this be done, or until some ancient manuscript of these poems shall have been published, all the arguments employed by Mr Laing will remain in full force and unshaken. It is no doubt true that Dr Blair has pronounced Ossian superior to Virgil, and that the Italian translator, Cesarotti, who implicitly adopted his opinion, has re-echoed the same extraordinary sentiment. This, however, is matter of taste alone; and as Dr Blair's Dissertation left the real question at issue exactly where the ingenious author found it, the same thing may, without any discourtesy, be affirmed of Dr Graham's Essay. The attempts made, in the latter work, to answer Mr Laing's arguments in detail, have signally failed in the object contemplated, particularly in all questions of a purely historical kind. In proof of this we need only refer to his confused notions respecting the origin of the Caledonians; the absurdities in which he has involved himself from not understanding the statements of Bede, upon which he professes to ground part of his refutation of Laing; and especially the extraordinary notion, contradicted by all history, that Ireland derived its Celtic population from Scotland. In grasping at straws, he also betrays a consciousness of the weakness of his cause, or the difficulty of the side which he has undertaken to defend. It may be true, as he alleges, and as several persons have testified, that Macpherson was not at first very profoundly skilled in the Gaelic language; but it is to be observed that this was his vernacular tongue, and that, at all events, he had the assistance of persons whose knowledge of the Highland dialect has never, as far as we know, been questioned or disputed.

But Dr Graham, when at a loss to resolve difficulties by an appeal to facts, has always a theory at hand to help him. The transmission of the poems of Ossian, by oral tradition, through a period of more than fifteen centuries, is acknowledged to be "a phenomenon of which we have no example in the history of literature." Yet we are desired to receive with undoubting faith this unparalleled anomaly; first, because, from the time in which these poems were composed till that in which "they were collected and translated by Macpherson, the Caledonians or Highlanders remained unconquered; and, secondly, because, in consequence of this permanency of political situation, their language remained unaltered, and unmixed with any foreign idiom." In this last point, however, Dr Graham contradicts himself, and makes an admission which appears of itself to be fatal to his theory. After informing his readers that the poems ascribed to Ossian "bear throughout the stamp of antiquity," he adds, "that *some foreign*, and *even some modern terms*, sometimes occur;" but that "still the Gaelic idiom is maintained, and the *purity* of its structure preserved inviolate." Nor is his reference to the supposed history of the poems of Homer, as a case in point respecting the alleged oral transmission of those ascribed to Ossian, much more fortunate than his theory of the immutable permanency and purity of the Gaelic language. For every scholar who has read Wolf's *Prolegomena ad Homerum* must be aware that this is neither more nor less than citing what is doubtful or improbable, in one case, to support what is at least equally doubtful or improbable in another. And as to the wonderfully retentive memory ascribed to the old Highlanders, it may be sufficient to observe, that this new theoretical element cannot be admitted upon a mere assumption without proof, and contrary to all experience or probability. Lastly, Dr Graham, anxious to dispose of the whole question at once, furnishes us with what he calls "a very obvious criterion of originality." "Mr James Macpherson," says he, "was brought up in the bosom of polished society; his mind was enriched with the stores of ancient and modern literature; he was familiarized, from an early period of life, to the modes of acting, and thinking, and expressing himself, which characterize the scholar of the present times. That a person of such education, and of such habits of thinking, should so completely divest himself of all his previous acquisitions in literature, and science, and of every idea rendered familiar to him by long use; and that he should be able to write with uniform consistency, in the character of a person who is supposed to have lived fourteen hundred years ago, and in a state of society so different from the present order of things; in short, that a modern European should produce such a work as the poetry of Ossian, distinguished exclusively by the ideas peculiar to people in the most simple state of society,—all these, I confess, I must consider as *efforts beyond the reach of humanity.*" We are not prepared to admit that the real case is here fairly stated, or that Macpherson has preserved the uniform consistency which Dr Graham has gratuitously ascribed to him; indeed Mr Laing has shown that, in numerous cases, the very reverse is the fact. But supposing that the doctor were correct to the letter in his statement of the question, it follows that Chatterton achieved an "effort beyond the reach of humanity," by the composition of the poems he ascribed to Rowley, which are entirely divested of every allusion to the modes and manners of the time when they were written, whilst the language is almost as faultlessly antique as that of the era to which the ingenious and unfortunate author chose to assign them.[1]

III. We come now to the Report of the Committee of the Highland Society, which, as a sort of judicial document, is particularly deserving of attention. The Committee in question was appointed for the express purpose of collecting all the evidence and information which could be obtained on the subject; and with this view it began by circulating a set of queries, embracing the principal points which had been brought into dispute in the controversy respecting the authenticity of the poems ascribed to Ossian. Its declared object was sedulously to avoid all controversy on the subject, and rather to collect materials from which a judgment might be formed respecting the question at issue, than to attempt to pronounce any formal decision of its own. In this spirit the Report was drawn up by Mr Henry Mackenzie, the chairman; and although there is a manifest and not unnatural bias in favour of the Celtic bard, yet, upon the whole, it displays a candour, fairness, and impartiality which, on a subject where national prejudices had been strongly excited, cannot be too highly commended. It only remains for us, therefore, to lay before our readers the results of this patient and laborious investigation, as these have been stated in the Report itself, and to leave them to form their own judgment.

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complished and enthusiastic author of the *Phingaleis*: "Jamque vale, mi Laingi: si fors resipueris; si te pœniteat; si reum tete confiteare, fas tibi mecum in amicitiam coire. Solemne namque fuit adeoque est Caledonibus,

Parcere subjectis, et debellare superbos."

[1] The *Gil Blas* of Le Sage is another instance in point. Though written by a Frenchman, it is, in sentiment, feeling, manners, and habits of thought and expression, as completely *Spanish*, as if it had been the production of Cervantes himself.

Ossian. Before proceeding, however, to submit to the Society the general conclusions at which they had arrived, the Committee felt themselves called upon to take notice "of some difficulties in this investigation, which have struck, and must strike, every impartial person at all acquainted with the subject, and conversant at the same time with the history of nations, and the progress of society." 1. The first of these is the circumstance of the language, in poems for which such a high antiquity is claimed, being so nearly what it still is, in the common use and understanding of the country. This has always been considered as a fatal objection; and, as we have already seen, it is forcibly urged by Mr Laing, who contends, that if the language had been ancient or obsolete, the poems could not have been preserved, and that the circumstance of its being modern is a proof that the poems could not be ancient. The Committee, however, suggest that "perhaps the situation of the Highlands and Islands, where this poetry has been preserved, and the little communication they had with other countries, may *in some measure* account for this circumstance." 2. Another preliminary difficulty adverted to is, that any human memory should have been able to retain poems of such length, and so numerous, as some of those Highlanders, from whose oral recitation the collectors of such poems professed to obtain them, are said to have repeated. The solution offered by the Committee is the common one, that "the power of memory in persons accustomed from their infancy to such repetitions, and who are unable to assist or injure it by writing, must not be judged of by any ideas or any experience possessed by those who have only seen its exertions in ordinary life;" and that "instances of such miraculous powers of memory" are known in most countries, "where the want of writing, like the want of a sense, gives an almost supernatural force to those by which that privation is supplied." 3. A third difficulty, which has always appeared to intelligent inquirers the hardest to be surmounted in this matter, is the style of manners and of sentiment exhibited in the poems ascribed to Ossian. The Committee reply, that in all the ancient Celtic poetry, a distinction is made between the Fingalian race and their invaders or enemies, the former assuming a degree of generosity, compassion, and delicate attention to the female sex, which is denied to the latter; and, besides, that some allowance ought to be made "for the colouring of poetry on the manners and sentiments of the heroic persons of whom it speaks." The real difficulty, however, is to explain how any poet living amidst barbarism, violence, and anarchy, could have conceived or imagined a style of manners and sentiment so different from all that he could ever have known or observed, and drawn such pictures of generosity, compassion, and gallantry, as are to be found in the poems of Ossian.

Having disposed of these preliminary difficulties, the Committee proceed to report, that there are two questions to which it has directed its attention, and on which it now submits the best evidence it has been able to procure. These are, 1st, What poetry, of what kind, and of what degree of excellence, existed anciently in the Highlands of Scotland, and was generally known by the denomination of *Ossianic*, from the universal belief that its father and principal composer was Ossian the son of Fingal? And, 2d, How far that collection of such poetry published by Mr James Macpherson is genuine?

In answer to the first of these questions, the Committee states with confidence an opinion "that such poetry did exist; that it was common, general, and in great abundance; that it was of a most impressive and striking sort, in a high degree eloquent, tender, and sublime." The second question, however, the Committee found it "much more difficult to answer decisively." It was possessed of no documents to show how much of his collection Mr Macpherson had obtained in the form in which he gave it to the world. The poems and fragments of poems they had been able to procure contained often the substance, and sometimes almost the literal expression, of *passages* given by Mr Macpherson in the poems of which he published translations. "But the Committee has not been able to obtain *any one poem the same in title and tenor* with the poems published by him. It is inclined to believe that *he was in use to supply chasms, and to give connection by inserting passages which he did not find, and to add what he conceived to be dignity and delicacy to the original, by striking out passages, by softening incidents, by refining the language*, in short, by *changing* what he considered as too simple or too rude for a modern ear, and *elevating* what in his opinion was below the standard of good poetry. To what degree, however, he exercised these *liberties*, it is impossible for the Committee to determine." Such is the deliberate judgment pronounced in the report; a judgment, we may observe, which disposes of the whole matter in dispute, by establishing the important fact, that there could exist no originals, in the proper sense of the term, from which Macpherson's *translations*, manufactured as they are here admitted to have been, could possibly have been derived. That he availed himself largely of the traditionary poems and ballads which formerly circulated in the Highlands, as in most other countries similarly situated, no one has ever denied or disputed. This, indeed, has been the opinion even of those who most strenuously contended that his pretended translations, taken as a whole, were spurious. But that there ever existed in the Gaelic language such long and connected poems as those of *Fingal* and *Temora*, seems to be now definitively decided in the negative. The Report concludes by stating, that the Committee "encountered many more difficulties, and was obliged to bestow more labour, than it was at all aware of when it undertook the investigation committed to it by the Society;" and it adds, that this labour "has, after all, *effected its purpose in a very imperfect manner*;" meaning, no doubt, in as far as regards the object originally contemplated, of establishing the authenticity of the poems ascribed to Ossian. In this "purpose," indeed, if such was entertained, it has entirely failed; but, on the other hand, it evinced perfect candour and impartiality in its researches, and acted throughout with a jealousy and circumspection which it rightly conceived to be due to itself, to the Society, and to truth.

IV. In order to render our view of this subject as complete as possible, it only remains to notice two other collectors of Gaelic poetry; namely, Mr Duncan Kennedy, and Dr Smith of Campbelton.

Mr Kennedy, originally a schoolmaster in Argyleshire, and afterwards an accountant in Glasgow, appears to have begun to collect Gaelic poetry somewhat prior to the year 1780; and his collection, consisting of three thin folio volumes in manuscript, having been purchased by the Highland Society of Scotland, is now in the possession of that body. Dr Graham, the author of the Essay already mentioned, having opened a correspondence with Mr Kennedy, called his particular attention to a passage in one of Dr Smith's letters to Mr Henry Mackenzie, in which the reverend gentleman states, that, on observing the beauty of one or two passages of some poems communicated to him by Kennedy, the latter said, *these were of his own composition;* and after stating to Kennedy how much it concerned his honour to take notice of this charge, Dr Graham invited him "to come forward, and make a fair acknowledgment of the share which he had in the business." Kennedy, nothing loth, obeyed the call thus made on him; and in his answer to Dr Graham's application, dated the 25th of October 1805, there is the following extraordinary,

Ossian.

and, we may add, instructive passage: "As the rage of both parties must soon subside, a fair division of property ought to take place, and poetical justice [to be] distributed between Ossian and the fabricators. It will, therefore, be admitted, at least by me, that Macpherson *has interpolated;* that Smith *has composed;* and that Kennedy, with much reluctance, *is forced to confess, that he has ventured to make some verses,* which, perhaps his vanity may deceive him, but he is inclined to think, *approach nearest to the genuine strains of Ossian that have yet been produced in the Gaelic language.*" In the same communication he declares that he composed about a sixth or seventh part of what is contained in the manuscripts purchased by the Highland Society; that the Death of Carril is entirely his own; that most of Bas Ossian he also claims; that considerable portions of the Death of Diarmid, Goll, Oscair, Garbh, Latha na Lìur, and other poems in the collection, are of his composition; and that "a good Gaelic scholar, of a good ear, and well acquainted with his imagery, and the qualifications and names of his favourite heroes and professed enemies, *may compose verses approximate to the excellence of the original, and which not one in a thousand will be able to distinguish from the real*" strains of Ossian. Here is a full, free, and instructive confession, which, although it excited the indignation and provoked the criticism of Dr Graham, who, no doubt, expected something very different, appears, nevertheless, to be distinguished for its frankness and candour, and which affords a significant hint of that process of manufacture which was pursued by Macpherson in concocting his pretended translations.

The next, and only other, collector we have to notice is the Rev. Dr John Smith of Campbelton, who, like Kennedy, performs a secondary part in this extraordinary literary imposture. It appears that Dr Smith had the use of Kennedy's manuscripts, and that he transcribed from them into his own collection whatever he conceived to possess merit. In the year 1780, Dr Smith gave this collection to the public in a translation; and, seven years afterwards, he published the *originals*, in an octavo volume, under the title of *Scandana*. Kennedy, however, in his letter to Dr Graham, distinctly states that Dr Smith "*composed*," or, in other words, fabricated originals; and as he has frankly acknowledged the share which he had in the fabrication of his own collection, the charge would carry considerable weight, even if it were not indirectly admitted by Dr Smith himself, which, as we shall presently see, is the case. Dr Graham, who appears to have been most unfortunate in the sources to which he applied for corroborative evidence, addressed a letter to Dr Smith, dated the 24th of March 1806, stating to him the confessions of Kennedy, including the charge of fabrication against Smith himself, and requesting that he would point out the manner in which he might be effectually vindicated from so disgraceful an imputation. Dr Smith, however, being less sensitive on this point than his correspondent, took the matter very calmly, and abandoned all his publications to their fate with the most stoical indifference. "On the subject of your letter," says the reverend gentleman, in reply, "I have long ago said all I have to say, and *take no further concern in the question.* If any allege he passed on me as ancient poetry what was his own composition, *I have no interest in disputing his allegation.* If I had, I would try if he could write such verses as he claims (no doubt the best) on any other given subject; and examine whether these passages were not *by a dozen or score of other contributors.* Unfortunately for me, not only one, but every contributor, dead or alive, must renounce his right, before I can take the merit of a verse or line, if vanity do not prompt me to take the contribution of such as are dead, and unable to dispute my claim. But this, I think, I shall leave to others; and if they claim the translation as well as the original, I will not dispute it, nor care who may believe and who may doubt it. The stopping of my plough by a shower of rain coming on gives me more concern than either." This is, perhaps, the most extraordinary answer that ever was made to a charge of literary imposture. Dr Graham says, "it will be found replete with good sense;" but, for our part, we discover in it merely a studied evasion of the important question, to which it so much concerned Dr Smith to give a distinct and unequivocal answer. It is some consolation, however, to find, that the strange proceedings in which this gentleman appears to have been engaged, were not, like those of Macpherson, productive of profit. The eyes of the public had already been opened; and, from one of Dr Smith's letters to Mr Mackenzie, we learn that "the *profits* of his publication were only a serious *loss*,"—a circumstance which affected him so sensibly, that he adds, "I could never since think of Gaelic poetry with pleasure or with patience, *except to wish it had been dead before I was born.*"

Ossification ‖ Ostend.

We have thus placed before our readers as complete and comprehensive a view of this famous controversy as our limits would possibly permit. The subject has no doubt lost much of its original attraction; indeed public opinion appears to have gradually settled down into a decided conviction, that the poems of Ossian, as they appear in the pretended translations of Macpherson, are substantially a forgery. But the controversy as to their authenticity or spuriousness, which was for a considerable time carried on with so much acrimony, forms a curious chapter in the literary history of Scotland; and, for this reason alone, we have endeavoured to exhibit a condensed view of the origin, the progress, and, we may add, the termination, of the dispute, at the same time furnishing such collateral information as seemed calculated to throw light upon the principal question agitated by the advocates and opponents of the Ossianic hypothesis. (A.)

OSSIFICATION, in the animal economy, the formation of the bones, but more particularly the conversion of parts naturally soft to the hardness and consistency of bones.

OSTADE, Adrian van, an eminent Dutch painter, was born at Lubeck in 1610. He was a disciple of Francis Hals, in whose school Brouwer was contemporary with him, and in it they contracted an intimate friendship. The subjects of his pencil were always of a low kind; he had nearly the same ideas as Teniers, and diverted himself with clowns and drunkards in stables, ale-houses, and kitchens. His pictures are so transparent and highly finished that they have the polish and lustre of enamel. They have frequently a force superior to Teniers; yet it were to be wished that he had not designed his figures so short. Of the Dutch masters he is perhaps the one who best understood the *chiaro oscuro;* and he was often employed to paint figures for the best landscape painters among his countrymen. He died in 1685. His works, especially those of his best time and manner, are very scarce; and hence, when they can be purchased, no price is thought too much for them. His prints etched by himself, large and small, consist of fifty-four pieces.

OSTEND, a city of Belgium, in the province of West Flanders, and circle of Bruges. It stands on the sea-shore, with a good harbour, and two basins. The entrance to the harbour is narrow, and only passable at high water; and at low water the vessels within are aground. The mouth of the haven is defended by two forts, and the town is surrounded with walls, and protected by two fortresses or citadels, being thus capable of defence against attacks either from the sea or from the land. It is well built; the streets are broad, and the houses good. It is connected by canals with Bruges and Nieuport, which are

Osteocolla. continued from the latter place to Dunkirk. It contains 10,550 inhabitants, many of whom depend on the sea and the internal navigation, and particularly on the fishery. It has considerable occupation in building ships, and in making sail-cloth and linen goods, besides cables and small cordage. It has also salt-refineries and saw-mills. But it is deficient in good water, which is conveyed from a distance of more than a mile. The siege of this place in the war between the Netherlands and Spain is one of the most memorable that history has recorded. It began in 1601, and ended in 1604, when it was surrendered to the Spaniards, who had lost before it 100,000 men. Long. 2. 28. 48. E. Lat. 51. 13. 37. N.

OSTEOCOLLA, ὀστεοκολλα, in *Natural History*, a white or ash-coloured sparry substance, in shape like a bone, and by some supposed to have the quality of uniting broken bones. It is found in long, thick, and irregularly cylindrical pieces, which are in general hollow, but are sometimes filled up with a marly earth, and sometimes contain within them the remains of a stick, round which the osteocolla had been formed. But though it is plain that many pieces of osteocolla have been formed by incrustations round sticks, yet the greater number are not so; in fact, they are irregularly tubular, and appear to be formed of a flat cake, rolled up in a cylindrical shape. The crusts of which these are composed do not form regular concentric circles round the internal cavity, as must have been the case had they been formed by incrustation. On the other hand, they plainly show that they were once so many thin strata, composing a flat surface, which has afterwards been rolled up, as one might do a paper three or four times doubled, into two, three, or more spiral lines. In this case, each single edge of the paper would be everywhere a regular point of a continued spiral line drawn from a given point; but they would by no means be so many detached concentric circles. The osteocolla is found of different sizes, from that of a crow-quill to the thickness of a man's arm. It is composed of sand and earth, which may be separated by washing the powdered osteocolla with water, and is found both in digging and in several brooks, in many parts of Germany and elsewhere. In some parts of Germany it is called hammosteus, from its always growing in sand, never in clay, or any solid soil, nor even in gravel. Where a piece of it anywhere appears on the surface, they dig down for it, and find the branches run ten or twelve feet deep. They usually run straight down, but sometimes they are found spreading into many parts near the surface, as if it were a subterraneous tree, the main stem of which began at twelve feet depth, and thence grew up in a branched manner till it was met by the open air.

The osteocolla found in the earth is at first soft and ductile, but in half an hour's time, if exposed to the air, it becomes as hard as we find it in the shops. The method of taking up a perfect piece for a specimen is to open the ground, clear away the sand, and leave it so for an hour or thereabouts, in which time it will harden, and may be taken out whole. It is certain that the osteocolla is produced at this time; for if a pit be cleared of it, more will grow there in a year or two, only it will be softer, and will not harden in the air so easily as the other. What the rotten substance resembling the decayed branches of trees is, we cannot determine, unless it really be such; but the opinion of the common people, that it is the root of something, is absurd, because its thickest part lies at the greatest depth, and the branches all run upwards. The osteocolla is a marly spar which concretes round this matter; but what it is that determines it to concrete nowhere on the same ground excepting around these branches, it is difficult to say. The rottenness of this substance, which forms the basis of the osteocolla, renders it very liable to moulder and fall away, and hence it is that we usually see the osteocolla hollow. Sometimes it is found solid; but in this case some vegetable matter has served as its basis, and instead of one branch, it will be found to have concreted about a number of fibres, the remains of which will be detected in it on a close examination. Osteology ‖ Ostiaks.

OSTEOLOGY is that part of anatomy which treats of the bones.

OSTERODE, a city of Hanover, in the province of Grubenhagen and bailiwick of Eimbeck. It is situated at the foot of the Hartz Mountains, on the rivers Sose and Apente, and is surrounded with walls. It contains 760 houses, with 4500 inhabitants. It has a gymnasium with six professors, and contains an extensive corn magazine, always stored with a large quantity of bread-corn for the supply of the miners of the Hartz. It has manufactures of various woollen goods, of cottons, and of hosiery; and, besides, white lead, small shot, snuff, and soap, with other small articles, are made there. Long. 10. 11. 24. E. Lat. 51. 14. 15. N.

OSTERVALD, John Frederic, a celebrated Protestant divine, was born at Neufchatel in 1663. He made such rapid progress in his studies that he became master of arts at Samur before he was sixteen years of age; and he afterwards studied at Orleans and at Paris. On his return to Neufchatel in 1699 he became pastor of the church there, and contracted a strict friendship with John Alphonsus Turretin of Geneva, and Samuel Werenfels of Basil; and the union of these three divines, which was called the Triumvirate of the Divines of Swisserland, lasted till his death. Ostervald acquired the highest reputation by his virtues, and his zeal in instructing his disciples; and he restored ecclesiastical discipline. He wrote many books in French, the principal of which are, 1. a Treatise concerning the Sources of Corruption; 2. a Catechism, or Instruction in the Christian Religion, translated into German, Dutch, and English, with an Abridgment of Sacred History prefixed to it; 3. a Treatise against Impurity; 4. an edition of the French Bible of Geneva, with Arguments and Reflections, folio; 5. Ethica Christiana; and, 6. Theologiæ Compendium. Ostervald died in the year 1747, regretted by all who knew him.

OSTERWICK, a city belonging to the Prussian province of Saxony, and the capital of a circle of the same name, which extends over 270 square miles, and contains 36,000 inhabitants. The city is situated on the river Ise, and is fortified. It contains 480 houses, with 2850 inhabitants, who are occupied in various manufactures, and carry on extensive breweries and distilleries. Long. 10. 36. 48. E. Lat. 51. 58. 18. N.

OSTIA, a town on the eastern coast of Italy, in the territory of the Roman see. It stands near that mouth of the river Tiber called Bocca del Fiumecino, in a marshy and unhealthy spot. It is the seat of a bishop, whose diocese is united with that of Velletria, and contains a large and fine cathedral. It is not on the spot where stood the Ostium of the ancients and the principal maritime establishment of Rome, which was stated to have been three or four miles in circuit, but somewhat farther from the seashore. The remains of the ancient city are still visible in the ruins of aqueducts, temples, and other edifices, which must have been built by a rich and luxurious population. The chief occupation of the few inhabitants consists in collecting salt made by the heat of the sun alone, and with which the greater portion of the papal dominions is supplied. Long. 12. 10. 30. E. Lat. 41. 45. 38. N.

OSTIAKS, an Asiatic tribe, who form the greater proportion of the native population of Siberia. They chiefly inhabit the banks of the Obi, in the government of Tobolsk, extending northward along the river to the frontier of the Samoiedes. They are extremely rude in their habits and manners. Considering indolence as their chief

Ostracism. enjoyment, they labour only from necessity. They are diminutive in their persons, being rather under than above the middle size; slender in their figures, with thin legs, and their faces pale and not at all strikingly marked. The visages of the men are particularly repulsive; nor do the women possess any superior attractions. They are simple, timid, and full of prejudices; and their only virtue seems to consist in hospitality, which they share in common with other savages. They are clothed in skins, without any shirt; and their lower garment consists of a species of jacket with sleeves, which reaches to the middle, whilst an upper garment, with a cap, is worn in cold weather. The female's attire is not particularly becoming. The headdress is adorned with bands of cloth fastened by ribbons, and by ear-rings of little coloured pearls. They tattoo also the back of the hand, and the fore part of the arm and of the leg. They are by no means distinguished for cleanliness, owing probably to the hard labour to which they are exposed; the men, as in all barbarous countries, regarding them as slaves. The Ostiaks live chiefly by fishing, and, with all the disgusting filthiness of savages, they eat their fish raw. Some of the rich have herds of rein-deer. With these they migrate along the banks of the rivers in portable tents, composed of pieces of bark sewed together; but in winter they dwell in wooden habitations, covered with earth to increase the heat. The filth and stench of their abodes cannot be described. In winter they sometimes engage in hunting, performing for this purpose long journeys on sledges. They are in general healthy; but when they advance in years they become liable to nervous and scorbutic disorders. The small-pox, in particular, has committed dreadful ravages amongst them. They are exceedingly rude in their religious notions, being generally pagans, and addicted to the grossest idolatries. They have in all their cottages idols, which are like dolls: these are placed in the neatest corner of the tent, with a little table before them to receive the offerings. Here they deposit, for the use of the idol, a large horn of snuff, with little pieces of willow bark, such as are here used for putting into their nostrils; and they often bedaub it with fish oil: but if any misfortune befall them which they imagine the idol might have averted, they cast it on the ground, and break it to pieces. The idols which are the chief objects of worship are in a wooded valley, the approaches to which are carefully guarded. They consist of a man and woman clothed in the Ostiak dress, finely adorned with their richest furs and cloths. The surrounding country is considered as sacred, so that they neither hunt upon it, nor cut down the grass nor any tree. They place great confidence in their sorcerers, and are deluded by the grossest and most absurd superstitions. They were governed, before the Russian conquest, by their own hereditary chiefs, who still administer justice amongst them; and the obedience exacted from them consists chiefly in the regular payment of their tribute of furs. Their amusements consist in dancing, or in romantic tales of their exploits and amorous adventures; and their language has a considerable affinity with that of the Finns. According to the census of 1784, the Ostiaks of the Obi amounted to 30,891 males.

OSTRACISM, in Grecian antiquity, denotes the banishment of such persons as by their merit or their influence gave umbrage to the people of Athens, lest they should attempt any thing against the public liberty. This punishment was called *ostracism*, from the Greek word ὀστρακον, which properly signifies a *shell*; but when applied to this object, it is used to signify the billet upon which the Athenians wrote the names of the citizens they intended to banish. The learned are divided with regard to the substance of which this billet was formed. Some insist that it was a small stone, or a piece of brick; others hold that it was a piece of bark; and others assert that it was a shell. The word admits of all these interpretations; but what determines its true sense, is the epithet applied to it by ancient authors, signifying "the punishment of potter's clay;" and this expression seems to prove, that the word ὀστρακον, when applied on this occasion, signified a "piece of baked earth, in the form of a shell;" an idea which the Latin authors had undoubtedly in their heads when they translated it by *testula*. The ancients are likewise divided respecting the time at which ostracism was instituted, but they all agree that the person who moved the law was its first victim. As to the name of its patron, and the time of its establishment, however, they differ extremely. Many are of opinion that ostracism originated at a very remote period in the history of Athens. Ostracism.

But however this may be, the punishment of ostracism was inflicted by the Athenians when their liberty was believed to be in danger. If, for instance, jealousy or ambition had sowed discord amongst the chiefs of the republic, and if different parties were formed, which threatened some revolution in the state, the people assembled to propose measures proper to be taken for preventing the consequences of a division which in the end might be fatal to freedom. Ostracism was the remedy to which they usually had recourse upon these occasions; and the consultations of the people generally terminated in a decree, by which a day was fixed for a particular assembly, when they were to proceed to the sentence of ostracism. The persons who were threatened with banishment then omitted no assiduity or art calculated to gain them the favour of the people. They made harangues to evince their innocence, and the great injustice which would be done them if they were banished. They solicited, in person, the interest of every citizen; and all their party exerted themselves on their behalf. They also procured informers to vilify the chiefs of the opposite faction. Some time before the meeting of the assembly, a wooden enclosure was raised in the forum, with ten doors, that is, with as many as there were tribes in the republic; and when the appointed day came, the citizens of each tribe entered at their respective door, and threw into the middle of the enclosure the small brick upon which the citizen's name was written whose banishment they voted. The archons and the senate presided at this assembly, and counted the billets. He who was condemned by 6000 of his fellow-citizens was obliged to quit the city within ten days; for 6000 voices, at least, were requisite to banish an Athenian by the ostracism.

The Athenians, without doubt, foresaw the inconveniences to which this law was subject; but they sometimes preferred exposing the innocent to an unjust censure, to living in continual alarms. Yet as they were sensible that the injustice of confounding virtue and vice would be too flagrant, they softened, as much as they could, the rigour of ostracism. It was not aggravated by the circumstances which were most dishonourable and shocking in the ordinary mode of exile, and the goods of those who were banished by ostracism were not confiscated. Such persons enjoyed the produce of their effects in the places to which they were banished, and their banishment was only for a certain time. But in common banishment, the goods of the exiles were always confiscated, and no hopes were given them of ever returning to Athens.

The scholiast of Aristophanes informs us of a third difference between ostracism and the common banishment, namely, that a particular place of retirement was assigned to those who were banished by ostracism, which was not appointed to the other exiles. There is reason, however, to suspect the truth of this observation. Themistocles was certainly not limited in his banishment. That great man, as we are told by Thucydides, though his chief residence was at Argos, travelled over all the Peloponnesus.

This punishment, far from conveying any stigma of infa-

Ostracites || Otabalo.

my, became, by the objects on whom it was inflicted, a proof of merit. Aristides the sophist, in his second declamation against the Gorgias of Plato, justly observes, that ostracism was not an effect of the vindictive spirit of the people against those whom it condemned; that the law, whether good or bad, was only meant to prune the luxuriant growth of transcendent merit; that it condemned to a banishment of ten years only those illustrious men who were accused of being exalted far above other citizens by their conspicuous virtue; and that none of that public indignation was shown to those exiled by ostracism, which commonly breaks out against criminals.

Such were the mitigations with which this law was introduced amongst the Athenians; and from them we perceive that the people were sensible of all the inconveniences to which it was subject. They were indeed too enlightened not to foresee that in many instances it might produce injustice; that if, in some respects, it would be favourable to liberty, in others it would be its enemy, by condemning citizens without allowing them a previous defence, and by making a capricious and envious people arbiters of the fate of great men; and that it might even become pernicious to the state, by depriving it of its best subjects, and rendering the administration of public affairs an odious employment to men of talents and virtue.

OSTRACITES, a name applied to the fossil oysters which are so common in many parts of England.

OSWESTRY, a market-town of the hundred of the same name, in the county of Salop, 182 miles from London, and seventeen from Shrewsbury. It is situated in a fertile district, and has a good market, which is held on Wednesday. Being a frontier town towards Wales, in ancient times it was an important place, frequently harassed, and often burned. The chief trade depends on the canal, which connects it with the Severn, the Dee, and the Mersey. It has a corporation of twelve aldermen and eighteen common councilmen. A recorder is chosen annually, who is generally the mayor of the preceding year. In 1801, the population amounted to 2672, in 1811 to 3479, in 1821 to 3910, and in 1831 to 4478; but the whole parish, at the last census, contained 8581 inhabitants.

OSYMANDES, or OSYMANDYAS, a famous king of Egypt. According to some, he was the first monarch who collected a great number of books for the purpose of forming a library; and this curious collection he is said to have entitled Pharmacy of the Soul.

OTABALO, a district or jurisdiction of South America, in the republic of Colombia, and department of the Equator or Quito. It contains eight towns or villages, the lands belonging to which are laid out in plantations, consisting principally of the sugar-cane; but wheat and barley both thrive uncommonly well. A number of small rivers fertilize the country, which abounds with sheep, black cattle, and horses. Great quantities of butter and cheese are exported; and the native Indians, who still inhabit their ancient territory, are a very industrious people, weaving quilts, cottons, bed-furniture, and carpets of very brilliant colours, which are much esteemed. There are two lakes in Otabalo, each about three miles in length by a mile and a half in breadth, one of which produces a cray-fish that is highly prized in Quito, being the only fresh-water fish that can be had there. The Indians of Otabalo resisted Huana Capac in his expedition against Quito, which so exasperated him that he ordered all who could be found to be beheaded and cast into a small lake in a neighbouring district; from which circumstance it received the name of Yagarchoca, that is, "the bloody lake." The town, which bears the same name as the district, is situated about thirty miles north from Quito, in 0° 15′ north latitude, and 77° 56′ west longitude. In the year 1818 it was said to contain 15,000 inhabitants, a great portion of whom were whites; but the population must have since that period decreased materially. The other towns and villages are not of much importance. Those of Cayambe and Catacatche are situated at the foot of the mountains which severally bear these appellations, the latter being between 16,000 and 17,000 feet above the level of the sea. Near Cayambe, on an eminence, are the ruins of an ancient circular temple, about fifty feet in diameter. Of this edifice nothing remains but the middle walls, which are about five feet in thickness and fifteen feet in height, the whole being constructed of unbaked brick, cemented with a sort of earth. In the plain near this village are numerous tumuli, or burying-places of the ancient inhabitants, which are generally of a conical shape. Many of these are of great size, and have been perforated for the sake of the gold utensils which were deposited in the earth along with the remains of the departed chief. In this manner not a few Spaniards at one time acquired considerable wealth; for in running a gallery through the tumuli, they came upon a number of golden idols, and jewels to a great amount. The ornaments and images made of the precious metals which have from time to time been discovered, are in general beautifully wrought, but thin and hollow. The emeralds also are cut into all sorts of shapes, and perforated with the greatest nicety; displaying altogether a degree of skill and finish far superior to what might have been expected from workmen whose only tools were made of hardened copper or stone.

Otaha || Otho.

OTAHA, one of the Society Islands, in the South Pacific Ocean, situated to the north of Ulietea, and surrounded with rocks. It was visited by Captain Cook in 1769, and afterwards, in 1791, by Captain Edwards. Long. 151. 20. W. Lat. 16. 53. S.

OTAHEITE, or TAHITI, a celebrated island of the South Sea, situated in west longitude 149. 13. and south latitude 17. 46., discovered by Captain Wallis in 1767. See the article POLYNESIA.

OTAKOOTAI, or WENOOAETTE, a small island in the South Pacific Ocean, about three miles in circumference, discovered by Captain Cook in 1777. Long. 201. 37. E. Lat. 19. 51. S.

OTHO, M. SALVIUS, a Roman emperor, born in the year 32, and of a family which claimed descent from the ancient kings of Etruria. Being among the number of Nero's favourites, he was raised to the highest offices of the state, and made governor of Pannonia, by the interest of Seneca, who wished to remove him from Rome, lest Nero's love for Poppæa should prove his ruin. After Nero's death, Otho conciliated the favour of Galba, the new emperor; but when he failed to gain his point, and Galba refused to adopt him as his successor, he resolved to make himself absolute, without any regard to the age or dignity of his benefactor. The great debts which he had contracted encouraged his avarice; and having procured the assassination of Galba, he made himself emperor. He was acknowledged by the senate and the Roman people; but the sudden revolt of Vitellius in Germany rendered his situation very precarious, and it was resolved that their respective pretensions to the empire should be decided by arms. Otho obtained three victories; but in a general engagement near Brixellum, his forces were defeated, and he stabbed himself when all hopes of success had vanished. This happened in the thirty-seventh year of his age, after a reign of about three months. It has been justly observed, that the last moments of Otho's life were those of a philosopher. He comforted his soldiers, who lamented his fortune, expressing his concern for their safety; and he observed, that it was better one man should die than that all should be involved in ruin on account of his obstinacy. His nephew was deeply affected, and feared exceedingly the resentment of the conqueror; but Otho comforted him by observing that Vitellius would be kind

and affectionate to his friends and relations, since, in the time of their greatest enmity, the mother of Vitellius had received the most friendly treatment at his hands. He also burned all letters which, by falling into the hands of Vitellius, might provoke his resentment against those who had favoured the cause of an unfortunate aspirant to empire. These noble and humane sentiments in a man who was the associate of Nero's disgraceful pleasures, and who had stained his hands with the blood of his master, have appeared to some wonderful, and have passed with others for mere craft and policy, rather than the suggestions of a naturally virtuous and benevolent heart. His father was a favourite of Claudius.

OTLEY, a town of the west riding of Yorkshire, in the wapentake of Skrack, 205 miles from London, and ten from Leeds, with a market on Tuesday. It is situated in a beautiful valley on the river Wharffe. The parish is very extensive, containing three chapelries and ten townships. The population of the town amounted in 1801 to 2332, in 1811 to 2602, in 1821 to 3065, and in 1831 to 3161. That of the parish, at the last census, amounted to 10,163.

OTODINI, ancient Britons, who, as some suppose, occupied the countries now called Northumberland, Merse, and the Lothians, to the north-east of the Brigantes. As the Otodini are not mentioned by any of the Roman historians, and noticed only by Ptolemy, it is consequently uncertain whether they formed a distinct and independent state, or were united with the Brigantes. They were a considerable people, however, and possessed a long tract of the sea-coast, from the river Tyne to the Frith of Forth. Their name is derived by Baxter from the old British words *Ot o dineu*, signifying "a high and rocky shore;" and thus descriptive enough of their country. They were probably reduced by Agricola at the same time with their more powerful neighbours the Brigantes; but as they lived without the wall of Severus, they were, like the rest of the Mæatæ, engaged in frequent revolts. In the most perfect state of the Roman government in this island, the country of the Otodini formed a part of the Roman province called Valentia, which comprehended the large tract between the two walls. As this province was never long in the peaceable possession of the Romans, the latter had but few stations in the country of the Otodini, except those along the line of the wall of Severus. Various authors have derived the name of this people in various ways, and it is very differently spelled; and different opinions seem still to be entertained amongst the learned respecting their real situation. Indeed it is even doubtful whether their country was in England or in Scotland.

OTRAHERMANA, La, a small island in the Eastern Seas, near the west coast of Lucon. Long. 120. 6. E. Lat. 15. 55. N.

OTRANTO, a province of the kingdom of Naples, on the Italian continent. It is the north-eastern corner of the kingdom, a kind of peninsula in the Mediterranean Sea, extending in north latitude from 39. 47. to 40. 48., and in east longitude from 16. 44. to 18. 41. The other boundaries on the land side are, on the north-west Bari, and on the south-west Basilicata. It is 1650 square miles in extent, and contains 292,100 inhabitants, of whom about 40,000 are said to be Arnauts and Greeks. A continuation of the Apennine chain runs through the centre of the province, but none of the points are very lofty, and they gradually decline in height till they terminate in the sea at Cape Leuca. On both sides of this ridge the land is of moderate quality, chiefly of a calcareous and clayey mixture; and when well fallowed, which, from a scarcity of manure, is the common practice, yields good crops of the common kinds of grain, and abundance of all sorts of pulse. Near to the shore, tobacco, cotton of a good quality, and much liquorice, are grown; and on the sides of the hills some very strong, if not well-flavoured wine, is produced, and also much olive oil. Silk is neglected, although the soil and climate are favourable to mulberry trees. Honey and wax are obtained in every village in plenty. There are no minerals, and the manufactures are insignificant. The chief city is Lecce.

OTTAJANO, a city of Italy, in the province Terra di Lavoro, in the kingdom of Naples. It is a large place, in a district producing considerable quantities of silk and olive oil, and abundant crops of corn. It contains three parish churches, and, including the adjacent village, 14,200 inhabitants.

OTTERBURN, a township in the parish of Eilsdon, of the county of Northumberland, and ward of Coquetdale, 308 miles from London, and thirty-two from Newcastle. It is remarkable for the battle fought there in 1383, between Henry Percy, usually called Hotspur, and the Earl of Douglas, a conflict which gave rise to the ancient ballad of Chevy Chase. It is on the north side of the Cheviot Hills, and the population amounts to about 400.

OTTERY, St Mary, a market-town of Devonshire, in the hundred of the same name, and 167 miles from London. It is situated on the river Otter, has a market which is held on Tuesday, some trade in making serges, and some in pillow-lace. In 1801 the population amounted to 2415, in 1811 to 2880, in 1821 to 3522, and in 1831 to 3849.

OTTICOTTA, a town of Hindustan, in the Carnatic, thirty-three miles north-east from Madras. Long. 81. 1. E. Lat. 13. 21. N.

OTUNGURRA, a town of Hindustan, in the province of Bahar, and district of Chuta Nagpore. Long. 85. 42. E. Lat. 23. N.

OTWAY, Thomas, an eminent tragic poet, was the son of Mr Humphrey Otway, rector of Woolbeding, in Sussex, and was born at Trottin, in that county, on the 3d of March 1651. He received the rudiments of his education at Winchester school, and in 1669 was entered a commoner of Christ-Church; but, from whatever cause, he left the university without a degree, and proceeded to London, where he commenced player. In 1672, he made his first appearance on the stage in the character of the king in the *Forced Marriage*, though with indifferent success, and soon found that he was not likely to gain much reputation as an actor. This inability to shine on the stage Otway shared with Shakspeare and Jonson, as he likewise shared some of their excellencies. It seems reasonable to expect, indeed, that a great dramatic poet should without difficulty become a great actor; that he who can feel might also express; that the man who can excite passion should be able to exhibit readily its external modes and indications. But experience has fully proved that, whatever be the affinity of these powers, one of them may be possessed in a great degree by a person who has very little of the other; and that they either depend on different faculties, or a different use of the same faculty. The actor must possess a pliancy of mien, a flexibility of countenance, and a variety of intonation, in which the poet may easily be supposed deficient; or the attention of each may have been differently employed, the poet considering thought and the player action, the one watching the heart and the other contemplating the expression of the countenance.

Otway, however, though sensible of his inability to attract notice as an actor, felt conscious of possessing powers which qualified him for becoming a dramatic author; and, under this impression, his very first attempt was made in the highest department of the art. His tragedy of *Alcibiades* was acted at the Theatre Royal in 1675, though with what measure of success we are not informed. The story is taken from Nepos and Plutarch; but in certain points he departs from history in order to accommodate the charac-

Otway.

ter of his hero to the effect which he wished to produce. *Don Carlos*, another tragedy in heroic verse, founded on St Real's novel of the same name, and the Spanish chronicles of the life of Philip II., was performed in 1676, and appears to have succeeded much better than any other of his plays. For many years indeed it was more applauded and followed than either *Venice Preserved* or *The Orphan;* and it is even asserted that it was played for thirty nights together, though this may reasonably be doubted. At any rate, it was very successful, and brought more money than any preceding tragedy.[1] In 1677, Otway produced *Titus and Berenice*, a piece in three acts, translated with alterations from Racine; and also *The Cheats of Scapin*, a farce partly taken from Molière; which were acted together with considerable success, the custom of annexing farces to plays having about that time been introduced. His comedy of *Friendship in Fashion*, which appeared in 1678, had also some success, though it seems doubtful whether the author was at this time in London, as he certainly went abroad during the year 1677.

The occasion of his going abroad will be immediately explained. Johnson, however, in introducing this circumstance, observes: "Want of morals, or of decency, did not in those days exclude any man from the company of the wealthy and the gay, if he brought with him any powers of entertainment; and Otway is said to have been at this time a favourite companion of the dissolute wits. But as he who desires no virtue in his companion has no virtue in himself, those whom Otway frequented had no purpose of doing more for him than to pay his reckoning. They desired only to drink and laugh; their fondness was without benevolence, and their familiarity without friendship." Men of wit received at that time no favour from the great except that of sharing their riots, from which they were dismissed again to their own narrow circumstances; and thus they languished in poverty without support, and often without resource. But some exception must, nevertheless, be made. The Earl of Plymouth, a natural son of the king, procured Otway a cornet's commission in some troops which were then, 1677, destined for Flanders. But the poet did not prosper in his military capacity. The society of dissolute wits had but ill qualified him for submitting to the restraints of discipline, or observing that regularity which the laws of the service required; and hence, having left his commission behind him, he returned to London, where he resumed his dramatic labours.

In 1680, he produced *Caius Marius*, a tragedy, which had some success, probably from the circumstance of the author having availed himself of the excitement that then prevailed about the Popish Plot; and, in the dissensions of Marius and Sylla, endeavoured to shadow forth the proceedings of the factions in the reign of Charles I. But a higher degree of fame awaited him from his next tragedy, *The Orphan*, which appeared the same year. This, as Johnson observes, is one of the few pieces which have kept possession of the stage, and pleased through all the vicissitudes of dramatic taste and fashion. It is a domestic tragedy, drawn from middle life, and its whole power is upon the affections. *The Soldier's Fortune*, and its second part, *The Atheist*, produced respectively in 1681 and 1684, were both successful, being far better suited to the manners of that age than to those of the present. The incidents and characters may, for the most part, be traced to other plays, and neither is in any respect worthy of the genius which, in 1682, gave to dramatic literature *Venice Preserved*, a tragedy, the fame of which, like that of *The Orphan*, is secure against all the caprices of taste and fashion, whilst it displays still higher powers of poetry and of expression. The striking passages are familiar to all, and its faults as well as its excellencies seem to have been rightly appreciated by the public. It is, in fact, the production of a man not very attentive to decency, nor over zealous for virtue, but of one who conceived forcibly, and drew originally by consulting nature in his own breast. Besides the plays already mentioned, he wrote the miscellaneous poems inserted in Johnson's series of the poets; and he translated from the French a History of the Triumvirate.

Otway.

But Otway's career was destined to be a short one. He died before completing his thirty-fourth year, on the 14th of April 1685, in a manner which has been variously represented; but, according to every account, in circumstances of the deepest distress. "Having," says Johnson, "been compelled by his necessities to contract debts, and hunted, as is supposed, by the terriers of the law, he retired to a public-house on Tower Hill, where he is said to have died of want; or, as is related by one of his biographers, by swallowing, after a long fast, a piece of bread which charity had supplied. He went out, as is reported, almost naked, in the rage of hunger, and finding a gentleman in a neighbouring coffee-house, asked him for a shilling. The gentleman gave him a guinea, and Otway going away bought a roll, and was choked with the first mouthful. All this, I hope," adds Johnson, "is not true; and there is this ground of better hope, that Pope, who lived near enough to be well informed, relates, in Spence's Memorials, that he died of fever caught by violent pursuit of a *thief* who had *robbed* one of his friends. But that indigence, and its concomitants, sorrow and despondency, pressed hard upon him, has never been denied, whatever immediate cause might bring him to the grave." Pope's account of Otway's death was first related by Warton in the notes to his Essay on that poet; and it differs in several particulars from the version of it given by Johnson. It would appear that an intimate friend of Otway's having been *murdered* in the street, the poet pursued the murderer on foot as far as Dover, where he was seized with a fever, occasioned by the fatigue, which afterwards carried him to his grave in London. By this account the robber is a murderer; and as Warton was more correct in stating facts than Johnson, it is probable that he relates the story exactly as he heard it. But it may nevertheless be traced to Spence, who, it seems, was informed by Dennis, the critic, that Otway had a friend, named Blakiston, who was shot in the street; that the murderer having fled towards Dover, Otway pursued him; and that, on his return, having drunk water when violently heated, he caught the fever which caused his death. Dennis, however, in the preface to his Observations on Pope's Translation of Homer, 1717, 8vo, says merely that Otway died in an alehouse; a statement which is not inconsistent with the preceding account, as, in point of fact, he generally lived in one. As to the story of the guinea and the loaf, it rests upon no sufficient authority, and may probably have been introduced to heighten the picture of the poet's distress, about which, unfortunately, there can be no doubt whatever. Some, however, are inclined to think that both accounts might be true. But this cannot be, for the supposition of Otway having died of fever, occasioned by fatigue, or by drinking cold water when violently heated, is

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[1] This circumstance is coarsely alluded to by Rochester in the *Session of the Poets:*

Tom Otway came next, Tom Shadwell's dear zany,
And swears, for heroics he writes best of any;
Don Carlos his pockets so amply had filled,
That his mange was quite cur'd, and his lice were all kill'd.

Otway, Cape ‖ Oudanulla.

altogether inconsistent with the story of his running half naked into the street in the rage of hunger, and being choked with the first mouthful of the bread purchased with the money that had been charitably given him. No one ever heard or knew of a patient in high fever being seized with raging hunger, and greedily devouring the first morsel of bread he could procure. The idea is altogether absurd.

When Otway first began to rise in reputation, Dryden spoke slightingly of his performances; but afterwards, when *The Orphan* and *Venice Preserved* had established his fame, fully acknowledged their merits. "To express the passions which are seated in the heart by outward signs," says he in his preface to Dufresnoy, "is one great precept of the painters, and very difficult to perform. In poetry the very same passions and motions of the mind are to be expressed; and in this consists the principal difficulty, as well as the excellency, of that art. This, says Dufresnoy, is the gift of Jupiter; and, to speak in the same heathen language, we call it the gift of our Apollo, not to be obtained by pains or study, if we are not born to it. For the motions which are studied are never so natural as those which break out in the height of a real passion. Mr Otway possessed this part as thoroughly as any of the ancients or moderns. I will not defend every thing in his *Venice Preserved;* but I must bear this testimony to his memory, that the passions are truly touched in it, though perhaps there is somewhat to be desired both in the grounds of them, and in the height and elegancy of the expression. But *nature is there*, which is the greatest beauty." This is high, and, at the same time, discriminating praise. Otway's power consisted in moving the passions and touching the heart. All the fountains of feeling were at his command, and he could throw them open at his pleasure. His mastery over the emotions as well as the passions of the soul was unrivalled. But he had not much cultivated versification, nor replenished his mind with general knowledge; and hence his numbers are sometimes harsh, and his allusions neither rich, varied, nor striking. "Nature," however, "is there," and her presence atones for every deficiency.

It appears that Otway, when he died, had about him the copy of a tragedy which he had sold for a trifle to Bentley the bookseller. An advertisement which appeared in L'Estrange's *Observator* for the 27th November and the 4th December 1686, in which a reward is offered to any person who "can give notice in whose hands the copy lies," leaves no doubt whatever of the fact. The play in question, however, seems to have been irrecoverably lost; for the tragedy entitled *Heroic Friendship*, which was printed in 1719, and attributed to Otway, is evidently no production of his. It never was acted, nor deserved to be acted. (A.)

OTWAY, *Cape*, a high and rocky promontory upon the south coast of New Holland. Long. 143. 29. E. Lat. 38. 51. S.

OTWEILER, a city of Prussia, in the province of the Lower Rhine, in the government of Treves. It is the capital of a circle of the same name, which extends over 178 square miles, and comprehends three towns and forty-seven communes, with 17,500 inhabitants. The city is situated on the river Blies, and contains two churches, 320 houses, and 2730 inhabitants, who are employed in making cloth, and some china-ware.

OUCH, a very ancient town of Hindustan, in the province of Moultan, the capital of a district, and probably the Oxydracoe of the Greeks. It is situated between the river Indus and the Sutlege or Hyphasis, and within the territories of the Bahawulpoor rajah. It is seventy-five miles south by west from the city of Moultan. Long. 70. 50. E. Lat. 29. 11. N

OUDANULLA, a small town of Bengal, in the district of Rajemahl, situated at the foot of a range of hills which approach near to the western bank of the Ganges. Near the town are the remains of a handsome stone bridge, a very fine specimen of modern Mahommedan architecture, built by the Sultan Sujah between 1640 and 1660. It was near this place that Major Andrews, in 1764, attacked and gallantly stormed the entrenched camp of the Nabob Cossim Ally. Long. 87. 45. E. Lat. 24. 55. N.

Oude.

OUDE, a province of Hindustan, situated between the twenty-sixth and twenty-eighth degrees of north latitude. On the north it is bounded by various petty districts tributary to Nepaul, from which it is separated by intervening hills and forests; on the south by Allahabad; on the east by Bahar; and on the west by Delhi and Agra. It is about 250 miles in length by 100 in breadth.

This province is part of the extensive plains of Hindustan, and is level in its surface, and extremely well watered, the Goggrah and Goompty Rivers running through it, both navigable by boats at all seasons of the year, and having the Ganges for its western boundary, besides numerous streams and lakes which intersect it in different directions. The soil is fertile, and, when properly cultivated, is exceedingly productive, yielding abundant crops of wheat, barley, rice, and a variety of other grains, cotton, sugar-cane, indigo, and poppies, and all the staple articles raised in India. It also produces grapes, mangoes, and other fruits. To the north-east the ground rises, and the country abounds in extensive woods and plains covered with grass, which afford cover for game and wild animals of all kinds. The air and the climate are suited to the spontaneous generation of nitre, from the brine of which an inferior kind of salt is produced. Lapis lazuli is also produced in this province; and a variety of cotton cloths and a coarse kind of flannel are made; also bows, arrows, shields, matchlocks, and swords. The climate is more temperate than that of Bengal. The hot winds commence about the middle of March, and blow with violence till about the beginning of June; but the inhabitants, nevertheless, contrive to keep their apartments very cool; and to the natives the hot winds are not unhealthy, however injurious to European constitutions. The rains are neither so violent nor of such long duration as in Bengal; and the temperature during the four cold months of the year is delightful. The principal towns of the province are Lucknow, Fyzabad, Oude, Khyrabad, Ghoorackpore, and Bahreich. The inhabitants are about one third Mahommedans; the remainder are Hindus of all castes. "All the villages," says Heber (vol. ii. p. 49), "have pagodas, while many are without mosques." They are a superior race both in body and in mind to the feeble natives of Bengal and of the districts round Calcutta. The Rajpoots, more especially, are distinguished by robust frames and by their military air, as well as by the more solid qualities of soldiers. The military habits of the population were long fostered by the disorderly state of the province, which, though it has no doubt improved, still affords too many opportunities to the freebooter.

Oude is celebrated in the ancient historical poems of Hindustan as an opulent and splendid empire, which extended all over the south of India, and even as far as the island of Ceylon. But these fabulous exaggerations are not deserving of credit. It was in the thirteenth century that Oude was conquered by the Mahommedan kings of Delhi, to whose empire it remained attached until its separation after the death of Aurungzebe, when it shared the fate of all the other parts of his kingdom, and from a dependent province grew up into an independent state. The first ancestor of the present ruler of Oude was Saadut Khan, a native of Rishapoor, in the province of Khorassan, who was appointed subahdar of Oude during the reign of Mahommed Shah. He was by birth a Persian, and came to India as a soldier of fortune; but by his courage and ad-

Oude. dress he rose by degrees to the rank of general in the imperial service, and was sent to the government of Oude. Having no sons, he sent for his nephew Mirza Mokiem to Persia, and gave him in marriage his only daughter, born of a concubine. He also introduced him into the imperial service, with the title of Suffder Jung, the defeater of armies. Saadut Khan died by taking poison, in consequence of the humiliating treatment he experienced from Nadir Shah, who invaded and overran India in the year 1739; and his son-in-law having secured possession of his treasure, succeeded to the throne, and was confirmed in the government of Oude by the emperor Mahommed Shah. Suffder Jung's reign was prosperous and successful. In the year 1747 he repulsed Ahmed Abdally, king of the Afghans; and, as the reward of his valour, he was honoured with the title of Abul Munsur, the victorious, and appointed prime minister, which was the origin of the title of vizier in his family. In addition to Oude, he also obtained a grant of the province of Allahabad; and at length, finding his influence upon the decline, and tired of the intrigues of the court, he died in 1753, or, according to some, in 1756. He was succeeded without opposition by Shuja ud Dowlah, who was successful in all his measures, until he took part with Cossim Ally Khan against the British, and was defeated by them in the battle of Buxar in the year 1764 (see HINDUSTAN, vol. xi. p. 419). He died in 1775, and was quietly succeeded by his eldest son Asoph ud Dowlah, a weak prince, who died in 1797. Having no legitimate children, he nominated one of his adopted sons, Vizier Aly, as his successor, who was dethroned by the British on account of his illegitimacy, and Saadut Ali, the eldest brother of the deceased nabob, was raised to the supreme power. It was in his reign that his dominions were dismembered, during the administration of the Marquis Wellesley; for an account of which the reader is referred to the article HINDUSTAN. The nabob of Oude had long agreed to pay an annual contribution to the East India Company, but was constantly in arrear, from the mismanagement of his affairs. On this account it was that, in lieu of this contribution, a portion of his territories was ceded to the Company, he being left sole ruler of the remaining portion. Great complaints have always been made against him by the British for the mal-administration of his dominions, which, there is no doubt, have often been a scene of serious disorders. He died in the year 1814, leaving a treasure, it is said, of many millions. Having been long on bad terms with his eldest son, he nominated his second as his successor. But the British, whose influence was now undisputed, refused to confirm his bequest, and elevated to the supreme power the eldest son, Ghazi ud Deen. The first act of the new ruler, in a conference which he had at Cawnpoor with the governor-general, was to solicit the acceptance of a crore (10,000,000) of rupees as a free gift. This was however declined, excepting as a subscription to the loan of six per cent. which was then open; and he afterwards agreed to the permanent assignment of 651,000 rupees annually, in payment of pensions due from the Oude treasury, under the guarantee of the British government. The Nepaulese war being protracted to a second campaign, and great preparations being made, and expense incurred, in the Pindarrie war, a hint was conveyed to the nabob that a second loan of a crore of rupees would be acceptable; and the nabob, knowing, no doubt, the power of those by whom the hint was given, cheerfully complied, and the amount was paid in bullion at Lucknow, from the treasures of his father. For the first time, the strip of low country, or Terriani, which bounds the hills, and which was taken from the Nepaulese, was given him, at his own suggestion. It is asserted, on the same authority of course, that he voluntarily tendered to the British the free gift of a crore of rupees. This territory which he consented to receive is either, as Bishop Heber mentions, a savage wilderness, or "occupied by a race of mountaineers, who pay no taxes without being compelled, and whom he has not the means of compelling." In short, the whole transaction, both the voluntary offer and the free gift, bears the aspect of fraud and extortion. Oude.

For more than fifty years the British have been interfering in the affairs of Oude, and under this superintendence the country has been gradually falling into decay and disorder. Their professed object has been to improve the interior administration, and the collection of the revenue. But in this case it is deeply to be regretted that their efforts should have been attended with so little success; for, according to the latest accounts, the country is a scene, in many parts, of anarchy, disorder, and extortion. The minister of the nabob, Hukeem Mendee, a man of considerable opulence, and, according to Heber, as respectable in his private conduct as most of the ministers in the East are expected to be, was dismissed at the instigation of the British; and a series of violent measures followed, in which many of the zemindars were proscribed and banished. Heber asserts,[1] that the worst consequence of the two loans to the British was, that it laid them under an obligation to the nabob, and prevented them from urging such measures as would have been necessary for the reform of the interior administration of the country. Hukeem Mendee, the displaced minister, had been continually introducing improvements in the collection of the revenue, after the examples afforded in the British provinces. The system adopted by the nabob was that of employing collectors or assessors, or officers who united both these duties, and whose sole object was to extort as much as possible from the impoverished peasantry and landholders, and to whose oppression there was no check. "In consequence," says Bishop Heber (vol. ii. p. 82), "three or four times more than the sums really due were often extorted by these locusts, who went down and encamped in different parts of the country, and, under various pretences, so devoured and worried the people that they were glad to get rid of them on any terms. Nay, sometimes, when one aumeen had made his bargain with the land-owners and tenants, and received the greater part of the payment in advance, a second would make his appearance with more recent powers (having outbid his predecessors), and begin assessing and collecting anew, telling the plundered villagers that they had done wrong to pay before it was due, and that they must look to the first man for re-payment of what they had been defrauded of. 'All this has been done,' was said to me, 'and the king will neither see it nor hear it.' It was not likely, however, to be done long without resistance. The stronger zemindars built mud-forts, the poor ryots planted bamboos and thorny jungle round their villages; every man that had not a sword sold his garment to procure one, and they bade the king's officers keep their distance. The next step, however, of government, was to call in the aid of British troops to quell these insurgents. This the king of Oude had, by the letter and spirit of existing treaties, a right to do. His father and uncle had purchased this right by the cession of nearly one third of their whole territories, by the admission of two or three garrisons of subsidiary troops into their remaining provinces, and by the disbanding of by far the greater part of their own army, on the express condition that the English should undertake to defend them against all external and internal enemies. Still Saadut Ali had used this right very sparingly. He was not fond of admitting, far less requesting, any more foreign interference

[1] Narrative of a Journey through the Upper Provinces of India, vol. ii. p. 81.

Oude. than he could help. And his own guards, consisting of two thousand regular infantry, one thousand horse, three hundred artillery, and the irregulars whom I have noticed, were enough for all usual occasions, and were in excellent order and discipline. Now, however, all was changed. The soldiers themselves were so ill paid that it was difficult to keep them together; the artillery, a beautiful little corps, first mutinied, and then disbanded themselves to the last man; and the king had really no option between either altering his system, or governing without taxes, or calling in British aid. That aid was demanded and given; and during the greater part of Lord Hastings's time this wretched country was pillaged under sanction of the British name, and under the terror of Sepoy bayonets, till at length the remonstrances of the British officers employed on this service became so urgent, and the scandal so notorious and so great, not to omit that the number of the disaffected increased daily, and that, the more parties were sent out in support of the aumeens (collectors), the more were called for, while every peasant who lost lands or property in the progress of the system became a decoit (gang-robber), and made inroads into the company's provinces, that a different course was imperiously forced on government."

The British resident was instructed to urge anew on the king a system of efficient reform. But he was extremely averse to the interference of the British, and accordingly the resident was instructed to decline granting military aid, unless some previous reforms should be carried into effect, and unless an English commissioner versed in such matters were allowed to accompany the detachment, and to determine, before resorting to extreme measures, on the justice of the collector's claims. The nabob evaded these peremptory demands, and begged that, as a preliminary step, the British force should be employed in putting down the rebellious zemindars, in destroying their mud-forts, and in disarming the people. Bishop Heber, however, observes, that the territories are in a far better state of cultivation than he expected to find them. From Lucknow to Sandee he says that the country is as populous and well cultivated as most of the Company's provinces. Since the aid of the British troops has been withheld, he adds that affairs have been in all respects growing better. The zemindars have in a few instances carried their point, and the collectors have been either driven away, or forced to accept a moderate compromise; and the chief sufferers are the king, who gets little or nothing of his undoubted dues, and the traveller, who, unless he has a guard, had better, as Bishop Heber recommends, sleep in a safe skin on the other side of the Ganges. "It should be observed, however," the same acute observer continues, "that I have as yet seen no sign of those mud-forts, stockades, and fortresses, on which the zemindars and peasantry are said to rely for safety; that the common people north of Lucknow are, I think, not so universally loaded with arms as those to the southward; and that though I have heard a good deal all the way of the distressed state of the country, as well as its anarchy and lawlessness, except in the single instance I have mentioned, where the treasure was attacked, I have *seen* no signs of either, or had any reason to suppose that the king's writ does not pass current, or that our aumeen would have the least difficulty in enforcing it in our favour, even without the small payment which I give, and which is evidently accepted as a gratuity. I cannot but suspect, therefore, that the misfortunes and anarchy of Oude are somewhat overrated, though it is certain that so fine a land will take a long time in ruining, and that very many years of oppression will be required to depopulate a country which produces on the same soil, and with no aid but irrigation, crops of wheat and pulse every year."

The territories of Oude reserved for the nabob occupy about 21,000 British square miles, and contain a population of at least 3,000,000 of inhabitants.

Oude ‖ Oudeypore.

OUDE, a town in the province of Oude, and the ancient capital of the above-mentioned province. It was long the residence of a Hindu dynasty, and subsequently the seat of the provincial government. It is situated on the south side of the Dewah or Goggrah River. It is described as having formerly been a city of vast extent; but nothing now remains to attest its former magnificence but a heap of ruins. It is still considered, however, as a place of great sanctity, and a resort of Hindu pilgrimage. In its vicinity are two remarkably large tombs of great antiquity, and venerated by the Mahommedans as the tombs of Seth and Job. There are no documents to tell at what period the seat of government was removed to Lucknow. But after the battle of Buxar in 1764, the nabob Shujah ud Dowlah founded the city of Fyzabad on the ruins of the ancient city of Oude, and the old city was in consequence demolished. It is eighty-five miles travelling distance east from Lucknow. Long. 82. 10. E. Lat. 26. 45. N. (F.)

OUDENARDE, a circle of the province of East Flanders, in Belgium, divided into eight cantons and 119 communes, and containing 156,500 inhabitants. The capital is the city of that name, situated in a fertile valley on the banks of the Scheldt. It is well built, and contains 950 houses, with 5300 inhabitants, who carry on extensive manufactures of fine linen. Lat. 50. 50. 40. N.

OUDEYPOOR, a Rajpoot principality in the province of Ajmeer, of which it occupies the south-eastern quarter. It is situated between the 24th and 26th degrees of north latitude. This territory formerly bore the appellation of Mewar or Meyar, and its chief is frequently styled in history the Rana of Chitore. So disorderly has for a long time past been the state of the country, that it is difficult to fix the real extent of the Oudeypoor territories, though they may be considered generally as comprehending the districts of Chitore and Mewar. In this view, they are bounded on the north by the Joudpoor territories; on the south by many native principalities in the provinces of Gujerat and Malwah; on the east by the territories of Kotah, Boondee, and Sindia; and on the west by the large district of Sarawy, nominally subject to Joudpoor. The whole area in 1818 might be estimated at 7300 square miles. The chief, who is of the Rajpoot or military tribe, the children of the sun, is esteemed to be of the proudest lineage in Hindustan. He is considered as the most noble of the Rajpoot chiefs, though he is much inferior in temporal power to the rajahs of Jeypoor and Joudpoor. He is said to be descended in the female line from Noushirvan the Just, who was sovereign of Persia at the birth of Mahommed; and thus he claims a common origin with the Seids, descended from Hossein the son of Ali. On this account he is much revered by the Mahommedans. The face of the country is in general rather hilly than mountainous, but when properly cultivated it is extremely fertile. It is watered by many streams, independently of the periodical rains; and yields in abundance sugar, indigo, tobacco, wheat, rice, and barley. It also possesses iron and sulphur mines, and abundance of fuel. It is a strong country, full of wild fastnesses and intricate paths. The country formerly possessed tin mines, which produced about three lacs of rupees annually, besides rich copper-mines in various parts. It is mentioned by Colonel Todd, that great riches were formerly extracted from these mines; but the miners are now dead, and the mines filled with water; and though a recent attempt has been made to work them, it was so unprofitable that the design was soon abandoned.

The Rajpoots form the aristocracy of the country, and are esteemed one of the purest of the Hindu tribes, and the most elevated in rank. The rights by which property is held in Oudeypoor, as well as throughout Northern India,

Oudeypoor.

and everywhere, indeed, except where they have been obliterated by conquest, are defined with singular perspicuity by Lieutenant-colonel Todd, in his great work on Rajasthan, in which the lights of philosophy are combined with the most laborious research, and a deep skill in the mysteries of Hindu literature. In the article HINDUSTAN we have endeavoured to give a view of the state of landed property throughout India; and in this province, where the ancient laws and customs still survive the rage of conquest, the ryot or cultivator is the original proprietor of the soil. This is, according to the learned writer referred to, an inherent right, which force only can destroy; whilst the title of the government is confined to a fixed rent; so that it is a common saying, "The government is owner of the rent, but I am master of the land." It is under this title that the land is held by the great chieftains and military vassals; the only claim of the crown being for a quit-rent, which in many cases has been commuted for military service. Land, however, is held by other tenures, as by a grant from the crown in lieu of services; and this grant may be recalled. But so sacred has the grant from the ryot been considered, that even monarchs have held lands on this tenure from their subjects. In the confusion and civil wars which distracted the country, many of these rights were lost; even the government dues were rarely levied, except by force; and the feudatories as rarely obeyed the summons of the chief to appear at his court. The province of Oudeypoor, together with Northern India, shared in the general confusion; and the repeated invasions of Scindia had spread such disorder throughout the country, that the revenues could not be collected. That of the rana had declined to eight or nine lacs of rupees; whilst petty states, such as Shahpoorah, Sherghur, and others, everywhere set up claims of independence. In consequence of these depredations, and the general disorder that reigned in the country, the rana was reduced to great poverty. His lands were usurped by predatory bands, and by the more systematic encroachments of Scindia and Holkar. A convention was agreed upon by the different chiefs, by which all extortion and plunder were to be suppressed. But though the most sacred oaths were exchanged in ratification of this treaty, the old scenes soon recommenced with increased violence. From this degrading bondage the rana of Oudeypoor was rescued by the interference of the British, who, as usual, exacted for their good offices a large tribute. His condition was, however, somewhat improved; his chiefs and nobles, and former feudatories, daily repairing to offer him their obeisance. But his poverty still continued, whilst his subjects were oppressed by his rapacious officers, who came in place of the plundering banditti who had been expelled by the power of the British government. The destruction of that predatory system under which Central India, and Oudeypoor amongst the other states, was so long oppressed, disorderly bands of Pindarries plundering the country, and connived at or assisted by Scindia and Holkar, was effected in the short campaign of 1817, when the Indian armies were all directed to march on Central India, and, not content with a defensive war, to attack the plunderers in their remote haunts, and entirely to root them up. The success of this war restored peace to Central India, and delivered the different rajahs and feudatories from the merciless exactions of the military banditti who had desolated the country.

"Of all the princes who obtained succour at this momentous crisis in the political history of India," says Colonel Todd, "none stood more in need of it than the rana of Oodipoor. On the 16th January 1818 the treaty was signed; and in February an envoy was nominated, who immediately proceeded to the rana's court to superintend and maintain the newly-formed relations. The right wing of the grand army had already preceded him, to compel the surrender of such territory as was unjustly held by the lawless partisans of Scindia, and to reduce to obedience the refractory nobles, to whom anarchy was endeared, from long familiarity." The strongholds of the country were soon surrendered to the victorious army, and tranquillity was restored. But an awful scene of ruin was exhibited. The rana, in his passage from Jehajpoor to Romulmer, a space of about 140 miles, at the time when he re-entered on the possession of his territories, found only two thinly-peopled towns, which acknowledged his authority. "All," says Colonel Todd, "was desolate; even the traces of the footsteps of man were effaced. The babool (*mimosa Arabica*) and gigantic reed, which harboured the boar and the tiger, grew upon the highways; and every rising ground displayed a mass of ruin." He adds, that he passed through Bhilwara, the commercial entrepôt of Rajpootana, in May 1806, when it was comparatively flourishing, and contained 6000 families. In 1818 it showed not a vestige of human existence. "All was silent in her streets; no living thing was seen, except a solitary dog, that fled in dismay from his lurking place in the temple, scared at the unaccustomed sight of man." Oudeypoor, the capital of the country, which formerly contained 50,000 houses within its walls, had not now 3000 occupied; the rest were in ruins, the rafters being taken for fire-wood. The produce to the revenue from the spring harvest of 1818 was only L.4000. Grain sold for three times the price at which it could be purchased within a distance of eighty miles; and the rana, whose ancestors had opposed Baber, Akbar, and Aurungzebe, during the splendour of the Mogul sovereignty, had not fifty horse to attend him, and was mainly indebted to Zalim Sing of Kotah for the means of subsistence. It was out of this state of confusion that order was to be restored. But the elements of prosperity, though scattered, were not extinct. The first point was the recognition of the prince's authority by his nobles, the surest sign of which was their presence in the capital; and such was now the paramount influence of British authority, that in a few weeks the rana saw himself surrounded by a court such as had not been known for half a century, and the whole feudal association of Mewar was embodied in the capital. Colonel Todd, in his great work already referred to, gives a striking picture of the restoration of order and prosperity in this country.

"To recall the exiled population," says he, "was a measure simultaneous with the assembling of the nobles; but this was a work requiring time. They had formed ties and incurred obligations to the societies which had sheltered them, which could not at once be disengaged or annulled. But wherever a subject of Mewar existed, proclamations penetrated, and satisfactory assurances were obtained, and realized to an extent which belied in the strongest manner the assertion that patriotism is unknown to the natives of Hindustan. The most enthusiastic and cheering proofs were afforded, that neither oppression from without, nor tyranny within, could expel the feeling for the '*bapota*,' the land of their fathers. Even now, though time has chastened the impressions, we should fear to pen but a tithe of the proofs of devotion of the husbandman of Mewar to the *solum natale;* it would be deemed romance by those who never contemplated humanity in its reflux from misery and despair to the sweet influences of hope. He alone who had witnessed the day of trouble, and beheld the progress of desolation, the standing corn grazed by Mahratta horse, the rifled towns devoted to the flames, the cattle driven to the camp, and the chief men seized as hostages for money never to be realized, could appreciate their deliverance. To be permitted to see these evils banished; to behold the survivors of oppression congregated from the most distant provinces, many of them strangers to each other, and the aged and the helpless awaiting the *lucky day* to take possession of their ruined abodes; was a sight which memory will not part with. Thus, on the 3d of Sawun (July), a favourite day with the husbandman, three hundred of all

Oudghir || Oufa.

conditions, with their waggons and implements of labour, and preceded by banners and music, marched into Kupasun; and Ganésa was once again invoked, as they reconsecrated their dwellings, and placed his portrait as the Janus of their portals. On the same day, and within eight months subsequent to the signature of the treaty, above three hundred towns and villages were simultaneously re-inhabited; and the land, which for many years had been a stranger to the ploughshare, was broken up. Well might the superstitious fancy that miracles were abroad; for even to those who beheld the work in progression it had a magical result, to see the waste covered with habitations, and the verdant corn growing in the fields where lately they had roused the boar from his retreat. It was a day of pride for Britain. By such exertions of her power in these distant lands her sway is hallowed. By Britain alone can this fair picture be defaced; the tranquillity and independence she has conferred, by her alone may be disturbed."

To give effect to all the measures necessary for the improvement of the country, proclamations were issued by the rana, inviting foreign merchants and bankers to establish connections in the chief towns throughout the country; branch banks were everywhere formed, and mercantile agents fixed in every town in the country; the shackles that bound external commerce were at once removed, and the multifarious posts for the collections of transit levies abolished; in lieu of which chain of stations, all levies on goods in transit were confined to the frontiers. Under this system, of which peace was the object, the country improved. Bhilwara, the chief commercial mart, rose rapidly from ruin, and in a few months contained 1200 houses, half of which were occupied by foreign merchants. In 1822 it contained nearly 3000 dwellings, inhabited by merchants, bankers, or artisans. Notwithstanding various obstacles to the prosperity of the country, from an impoverished court, avaricious and corrupt officers, the discontent of the head men of the village, and bad seasons, the general prosperity advanced rapidly; and of this the increase of the revenue and population, as exhibited below, is a sure index.

Abstract of the land and commercial revenues of Mewar in the following years: Spring harvest of 1818, 40,000 rupees; of 1819, 451,281; of 1820, 659,100; of 1821, 1,018,478; of 1822, 936,640. Comparative population of the chief towns before and after four years of peace:—

	No. of houses in 1818.	No. in 1822.
Oodipoor,	3500	10,000
Bhilwara,	none	2,700
Poorh,	200	1,200
Mandel	80	400
Gooosonda	60	350 (F.)

OUDGHIR, a populous village of Hindustan, situated in the province of Bejapore, with a small fort and handsome cypress garden. It is in the nizam's dominions, and is 115 miles north-west from Hyderabad. Long. 77. 25. E. Lat. 18. 19. N.

OUEINING, a city of China, of the first rank, situated on a fine lake in an extensive plain, surrounded with high mountains. Long. 103. 50. E. Lat. 26. 45. N.

OUE-KIUN, a city of China, of the first rank, in Honan, being situated on a river, in a sandy plain and barren soil.

OUEN-TCHEOU, a city of China, of the first rank, in Tchekiang, situated on a river, with a good harbour. Long. 129. 29. E. Lat. 28. 1. N.

OUFA, a considerable city of Asiatic Russia, and capital of the government of Orenburg. It is situated on the banks of the Belaia, near its junction with the Oufa; part of it is a species of hollow resembling a cavern, and its site is intersected by numerous torrents and ravines. It was built in 1573, by the Czar Ivan Vassilievitch, as a station to collect the tribute of the Baschkirs, and as a barrier against the inroads of the Kirghisses. It was once fortified; but the fortifications have now fallen into decay, the danger of invasion having diminished with the extension of the frontier. This place is the residence of the primate, who bears the title of Archbishop of Orenburg and Oufa. It contains about 1000 houses, and nearly 2500 inhabitants of both sexes. It has seven churches, two convents, one of which is destined for nuns, an academy, and two schools. The surrounding country is fertile, abounding in forests and pastures, and well suited for the rearing of bees; and the Tartars who dwell in the neighbourhood, being the most diligent and industrious cultivators in Siberia, have acquired considerable wealth. It is asserted that there was formerly on the spot where Oufa stands a great Tartar city, the residence of the khans of the Nogais; and this tradition is confirmed by many ancient relics found near the city, amongst which are two mosques built of brick, and several remarkable sepulchral monuments, with Asiatic and Cufic inscriptions. Long. 56. 18. E. Lat. 54. 42. N.

Oufa || Ourcha.

OUFA, a considerable river of Russia, which rises in the Oural Mountains, and falls into the Belaia, near the city of Oufa. Its course is through a mountainous and fertile country; and several of its tributary streams have rich mines of iron on their banks.

OUGHTRED, WILLIAM, an eminent mathematician, was born at Eton in 1573, and educated in the school there, whence he was elected to King's College, Cambridge, of which he afterwards became fellow. Being admitted to holy orders, he left the university about the year 1603, and was presented to the rectory of Aldbury, near Guildford in Surrey; and about the year 1628 he was appointed by the Earl of Arundel to instruct his son in the mathematics. He kept a correspondence by letters with some of the most eminent scholars of his time on mathematical subjects; and the most celebrated mathematicians of the age owed most of their skill to him, his house being full of young gentlemen who came from all parts to receive his instruction. It is said that, upon hearing the news of the vote at Westminster for the restoration of Charles II. he expired in a sudden transport of joy, at the age of eighty-eight. He wrote, 1. *Clavis Mathematica*, which was afterwards published in England; 2. A Description of the Double Horizontal Dial; 3. *Opuscula Mathematica;* and several other works.

OUKESIMA, an island in the Chinese Sea, near the coast of Tonquin, about thirty miles in circumference. Long. 105. 42. E. Lat. 18. 44. N.

OULLER LAKE, a lake of Hindustan, in the province of Cashmere, into which the river Behut or Jhylum pours its stream. Long. 73. 50. E. Lat. 34. 22. N.

OUNCE, a weight, the sixteenth part of a pound avoirdupois, and the twelfth part of a pound troy. The word is derived from the Latin, *uncia*, the twelfth part of any whole, called *as;* and, in geometrical measures, an inch, or twelfth part of a foot.

OUND, a village of Hindustan, in the Mahratta territories, and province of Bejapoor. The surrounding district is the property of Scindia's family. It is nine miles from Poonah.

OUNDLE, a market-town of the county of Northampton, and the hundred of Polebrook, seventy-eight miles from London, and sixteen from Stamford. It has a good market, which is held on Saturday, and is nearly surrounded by the river Nen, over which are two bridges, one of them a curiosity, from the number of its arches, as well as from the causeway leading to it. The population amounted in 1801 to 1956, in 1811 to 1833, in 1821 to 2150, and in 1831 to 2308.

OURCHA, a town of Hindustan, in the province of Al-

lahabad, and district of Bundelcund. The rajah was formerly a person of great note; but his revenue is now reduced to one lac, and his consequence has sunk in proportion. He is still considered as the head of the petty chiefs of Bundelcund.

OURAL MOUNTAINS, a remarkable and extensive range of mountains, which has its commencement in the interior of Asia, in the territory of the Kirghisses, between the Caspian and the Aral, and stretches about due north along the sources of the Oural, the Tobol, the Emba, the Petchora, and the Sosva, by a course very imperfectly known, but, it is supposed, nearly parallel to the course of the Obi, to the shores of the Northern Ocean, and across that ocean throughout the whole length of Nova Zembla. It forms, during the greater part of its course, the boundary between Northern Asia and Russia in Europe. The soil and the country are very various, great part of these mountains being little else than lofty and barren deserts. Hence this extensive tract is divided into the Oural of the Kirghisses, the mining district of the Oural, and the desert regions. No accurate information has been obtained, excepting regarding the mining district, which contains extensive mines of iron and copper, with several of gold and of platina. Great establishments have been formed in these desert parts for the working of the mines, the produce of which has been increasing in value for the last twenty years. Besides these metals, the Oural Mountains also produce varied and beautiful specimens of minerals, as jasper, quartz, petrosilex, agate, calcedony, rock crystal, topaz, amethyst, chrysolite, asbestos, amianthus, and others. The Oural Mountains slope much more on the western than on the eastern side; and on the former there is a collateral chain, which contains rich veins of copper. Many of the loftiest pinnacles are composed of granite, which appears below in large masses; and they reach above the level of perpetual snow. The sides, particularly the western, are composed of schistus, whilst, in the lower parts, calcareous rocks predominate. These mountains are covered in many parts with forests, in which are generally found pines, cedars, larches, and other natives of a northern climate; and in the south-west parts are found the oak and the ash. Between the mountains are seen fine pasture-grounds, rich valleys, and beautiful meadows, in which numerous herds of cattle are bred. The country is well watered, both by numerous rivers, and fine transparent lakes full of fish.

OURAL, a large river of Asiatic Russia, formerly called by the name of Yaik. It received its present appellation in the year 1775. It has its rise in the Oural Mountains, in about 54° north latitude, and runs westward a great part of its course, after which it turns directly south, and falls into the Caspian, nearly in 47° north latitude, and 53° east longitude. It forms the boundary between the Kirghisses and the Baschkirs; has a rapid current, with a pure stream; and everywhere abounds with fish, the fisheries on its banks affording an inexhaustible source of wealth to the Cossacks. It has very steep and rocky banks whilst it is a mountain stream; but afterwards flows through a dry and saline plain.

OURALSK, a large and populous city, with narrow and irregularly built houses, the capital of the Oural Cossacks. The male inhabitants, who amount to 3600, are divided into seven regiments, which are under the general superintendence of the governor-general of Orenburg. They are chiefly employed in taking fish, which are very abundant in the Oural, and are considered to be superior in quality to those caught in the Caspian. The place is surrounded with palisades and an irregular rampart. Long. 52. 6. E. Lat. 50. 11. N.

OURFA. See ORFA.

OUROOMIA, or OOROMIA, the chief town of a district or government of the same name, in Persia, situated on a large lake, also of the same name, in the province of Azerbijan. It is an ancient city, which, according to Sir Robert K. Porter, once bore the name of Thebarma; and is mentioned as a place of some consequence by Strabo. It is surrounded with walls and towers, which are at present in a very ruinous state, though, with a shallow ditch, they constitute its only means of defence. It is, however, beautifully situated amidst the most extensive and luxuriant gardens, producing almost every European and Asiatic fruit in the greatest plenty and perfection. The town contains, according to Frazer, about 20,000 inhabitants, who are of disorderly habits, being mostly the immediate retainers of chiefs who, having their property in the neighbourhood, reside in large palaces within the town. The latter have constant feuds with each other, in which their retainers take part; and the governor, who is a chief of the Affshar tribe, being quite unable to restrain them, more murders are committed in the town of Ouroomia than in any other city of Persia. It is sixty miles west of Tabreez. Long. 46. 12. E. Lat. 37 58. N.

OUROOMIA, *Lake*, a noble expanse of water, about 100 miles in length, stretching nearly north and south, and about forty miles in breadth. It is surrounded by picturesque mountains, and valleys which are fertile and well filled with villages. It lies to the south-east of Koiy, at no great distance from the city; and is generally considered as the Spauto and Marcianus of Strabo and Ptolemy. Its waters, like those of the sea, appear of a dark blue colour, streaked with green, according as the light falls on them; they are perfectly clear, and intensely salt. According to an experiment by the late Mr Brown, they were found to contain one third more salt than the sea. A great quantity of salt is also deposited on the shores, and on the bottom, which is seen for a considerable distance, from the clearness of the water. In some places there is an incrustation of salt towards the margin, from under which, when broken, thick concentrated brine rushes out; and the deposition of salt and saline efflorescence extends in some places many hundred yards from the water's edge, encircling it with a belt of glittering white. No fish or living thing, says Frazer, as far as is known, has been found in this fine lake. Within the last twelve or fourteen years, the same traveller was informed that the waters had gone back, and left the shore dry, in some places, to a distance of full 500 yards. From the village of Sheraff-Khaneh, built upon a bank once overhanging the water, it has retired, leaving a mud beach, covered with salt or saline efflorescence, of many hundred yards in breadth. A finer subject for inland navigation than this lake and its tributary streams can scarcely be conceived. The country from Tabreez to its bank is level, and the river Adjai, which passes the town, could easily be converted into a canal, or made to feed one; and by this channel the valuable produce of all the districts around the lake of Ouroomia might be brought to the capital at a trifling expense. But the spirit of enterprise in Persia is broken under the influence of a despotic and unstable government; and hence it is in vain to expect that capital will ever be employed in any useful improvement. So little disposition is there to take advantage of this lake for inland navigation, that there is not a single boat upon it. There were formerly two; but one was wrecked, with the loss of eight men, and the other was allowed to rot. The district or government of Ouroomia contains, according to Frazer, 400, and to Sir Robert K. Porter, 700 villages. It has been ruled by the present governor and his family for 200 years. Its revenue amounted for twenty-five years to 7000 tomaums, or about L.15,000 annually. But since the rivalry of certain noblemen with each other for the government, it has been increased to L.100,000, which is wrung from the poor peasantry by the most cruel extortion.

OURRY'S ISLAND, or NEW ALDERNEY, an island in the South Pacific Ocean, discovered by Captain Carteret

Ouse ‖ Ovation.

in 1767. It is one of the Queen Charlotte Islands, and is ten miles long and five broad. Long. 165. 19. E. Lat. 11. 10. S.

OUSE, GREATER, a river which rises near Fitwell, in Oxfordshire, and proceeds to Buckingham, Stony Stratford, and Newport-Pagnel, in Buckinghamshire; from thence it proceeds to Bedford, and turning north-east, it passes on to Huntingdon and Ely, till at length it arrives at Lynn-Regis, in Norfolk, and falls into the sea.

OUSE, *Smaller*, rises in Suffolk, and, separating that county from Norfolk on the south-west, discharges itself into the Great Ouse near Downham. There is still another of the same name, which rises on the west-north-west side of Yorkshire, and running chiefly to the south-east, at length falls into the Humber.

OUSSOOR, a town of Hindustan, in the Mysore rajah's territories, which surrendered to a British detachment in 1791. Long. 78. E. Lat. 12. 45. N.

OUTCHANG-FOU, a city of China, of the first rank, situated on the great river Yang-tse-kiang, at its junction with the Han. It is the capital of the province of Houquang, and when joined to Hang-yang-fou, situated on the opposite side of the river, and forming properly one with it, it ranks with the largest cities in China, or in the world. From its position at the junction of the great river Yang-tse-kiang with the Han, it enjoys an easy commercial intercourse with almost every port of China. Though nearly 500 miles from the sea, the river is deep enough to float the largest vessels; and, for some miles in the vicinity of the city, it is entirely covered with barks, amounting to 8000 or 10,000, many of which form the only habitation of numerous Chinese families. This interminable prospect and forest of masts presents one of the most striking scenes in the world. The surrounding country is noted for the excellence of the tea which it produces; and the bamboo paper manufactured here is very highly celebrated all over China.

OU-TCHEOU, a city of China, of the first rank, in the province of Quang-see. It is favourably situated for commerce, as the whole rivers of the province meet under its walls in their progress to Quang-tong. The surrounding country is mountainous. The rhinoceros is found in the neighbouring rivers. Long. 110. 32. E. Lat. 23. 38. N.

OUTING, a city of China, of the first rank, in the province of Yunan, situated in a fertile country, near a range of very rugged mountains, which yield abundance of musk. It is exposed to the inroads of the mountaineers, for which reason a considerable garrison is maintained in the place. Long. 102. 6. E. Lat. 25. 53. N.

OUTLAW signifies one who is deprived of the benefit of the law, and therefore held to be out of the king's protection.

OUTLAWRY, the punishment of a person who, being called into court, and sought, according to the usual forms, does contemptuously refuse to appear.

OUVAROFSKOI, a fort of Asiatic Russia, in the government of Tomsk. It is agreeably situated, contains twenty houses, and has been erected as a bulwark against the Kirghisses.

OVAL, an oblong curvilinear figure, otherwise called *ellipse*. The proper oval, or egg shape, however, differs considerably from that of the ellipse, being an irregular figure, narrower at one end than at another; whereas the ellipse or mathematical oval is equally broad at each end. But it must be owned that these two are commonly confounded, even geometricians calling the oval a *false ellipse*.

OVATION, in Roman antiquity, was a lesser triumph, allowed to commanders for victories won without the effusion of blood, or for defeating a mean and inconsiderable enemy. The show generally began at the Alban Mountain, whence the general with his retinue made his entry into the city on foot, with many flutes or pipes sounding in concert as he passed along, and wearing a garland or myrtle as a token of peace. The term *ovation*, according to Servius, is derived from *ovis*, a sheep, because on this occasion the conqueror sacrificed a sheep, as in a triumph he sacrificed a bull. The senate, knights, and principal plebeians assisted at the procession, which concluded at the Capitol, where rams were sacrificed to Jupiter. The first ovation was granted to Publius Posthumius, for his victory over the Sabines in the 253d year of Rome.

Oven ‖ Overall.

OVEN, a kind of domestic furnace, used for baking bread, pies, tarts, and the like. It is of a circular structure, with a very low roof, well lined both on the top, bottom, and sides, with stone; and it has a small entrance in the front, fitted with a door, which being clapped to the mouth of the oven, confines the heat, whilst bread, pies, or puddings, are baking. Over this pastry-cooks have another oven built much in the same manner, which is used for such things as require a less degree of heat. Ovens are heated by burning in them dry faggots, wood, &c. till all the parts are equally hot.

OVERALL, JOHN, a celebrated English bishop, was born in 1559, and, after a proper foundation in grammatical learning, was sent to St John's College, Cambridge, and elected a scholar of that society; but having afterwards removed to Trinity, he was chosen fellow of that college. In 1596 he was made regius professor of divinity, when he took his degree of doctor, and about the same time was elected master of Catherine Hall. In 1601 he was promoted to the deanery of St Paul's, London, by the recommendation of his patron, Sir Fulke Greville, and Queen Elizabeth; and in the beginning of King James's reign he was chosen prolocutor of the lower house of convocation. In 1612 he was appointed one of the first governors of the Charter-House Hospital, then just founded by Mr Thomas Sutton. In April 1614 he was made Bishop of Litchfield and Coventry; and in 1618 he was translated to Norwich, where he died in May 1619, at the age of about sixty. He was buried in that cathedral, where he lay unnoticed and forgotten till some years after the restoration of Charles II., when Cosin, bishop of Durham, who had been his secretary, erected a monument, with a Latin inscription, in which he is said to be "Vir undequaque doctissimus, et omni encomio major."

Wood observes, that he had the character of being the best scholastic divine in England; and Cosin, who perhaps may be thought to rival him in that sort of learning, calls himself his scholar, and declares that he derived all his knowledge from Overall. He is also celebrated by Smith for his distinguished wisdom, erudition, and piety. In the controversy about predestination and grace, which in his time divided the reformed churches, he held a middle opinion, inclining somewhat to Arminianism. He seems indeed to have paved the way for the reception of that doctrine in England, where it was generally embraced a few years afterwards, chiefly by the authority and influence of Archbishop Laud. Overall cultivated a particular friendship with Gerard Vossius and Grotius, and was much grieved to see the love of peace, and the projects of the latter to obtain it, so ill repaid. He himself laboured heartily to settle the differences in Holland, upon what is known by the name of the Quinquarticular Controversy; as appears in part by his letters to the two learned correspondents just mentioned, some of which are printed in the *Epistolæ Præstantium Virorum*.

This bishop is known in England chiefly by his Convocation Book, of which Burnet gives the following account: "This book was wrote on the subject of government, the divine institution of which was very positively asserted. It was read in convocation, and passed by that body, in order to the publishing of it, in opposition to the principles

Overbury || Overhauling.

laid down in the famous book of Parsons the Jesuit, published under the name of Doleman. But King James did not like a convocation entering into such a theory of politics; so he discouraged the printing of it, especially since, in order to justify the owning of the United Provinces, who had lately thrown off the Spanish yoke, to be a lawful government, it was laid down, that when a change of government was brought to a thorough settlement, it was then to be owned and submitted to, as a work of the providence of God. Here it slept, till Archbishop Sancroft, who had got the book into his own hands, and not observing the last-mentioned passage in it, resolved to publish it, in the beginning of King William's reign, as an authentic declaration which the Church of England had made in the point of non-resistance. Accordingly it was published in quarto, as well as licensed, by him, a very few days before he was under suspension for not taking the oaths.

OVERBURY, Sir Thomas, a learned Englishman, was born in 1581, and studied at Queen's College, Oxford, after which he removed to the Middle Temple, London. He then travelled for some time, and returned a most accomplished person; after which he contracted an intimate acquaintance with Sir Robert Carr, knight of the Bath, who being soon afterwards taken into his majesty's favour, procured Overbury the honour of knighthood. Sir Thomas perceiving the familiarity which subsisted between his patron Carr, now Viscount Rochester, and the Lady Frances, the wife of Robert Earl of Essex, was so much displeased at it that he endeavoured to dissuade Lord Rochester from keeping her company, and from proceeding in the base design he had formed of having her first divorced from her husband, and then marrying her. The viscount, resenting this honest advice, told all he had said to the lady, who was as remarkable for her wickedness as for her beauty; upon which they immediately resolved to effect his destruction. About this time, the king having occasion to send an ambassador abroad, Rochester recommended Sir Thomas Overbury. His majesty approved the choice, and the viscount imparted the king's intentions to Sir Thomas; but, under a treacherous show of friendship, dissuaded him from accepting of that employment, as it might hinder him from a better way of advancement, promising that he would prevent his majesty from being displeased at his refusal. The viscount then went to the king, and having artfully incensed his majesty against Sir Thomas for refusing to obey his commands, the latter was, on the 21st of April 1613, committed for contempt to the Tower, where he continued a prisoner till he was despatched by poison on the 15th of September following. About two years afterwards the whole contrivance of his death was discovered. On this several persons were condemned and executed; but though Carr, now Earl of Somerset, and the Lady Frances, his countess, were condemned to death for contriving the murder, and hiring the persons who were concerned in it, the king only banished them from court, and afterwards pardoned them. Sir Thomas Overbury obtained considerable reputation as an author, both in prose and in verse; but it is probable that the compassion excited by his unhappy end may have at first imparted to his works a degree of popularity which they have not since retained. The principal are, 1. The Wife, a long poem, filled with sentiments, maxims, and observations, such as considerable experience and a correct judgment of mankind could alone supply; and, 2. Characters and Descriptions of the Properties of Sundry Persons, which afford a favourable specimen of his prose style.

OVERHAULING, the act of opening and extending the several parts of a tackle, or other assemblage of ropes, communicating with blocks or dead eyes. It is used to remove those blocks to a sufficient distance from each other, that they may again be placed in a state of action, so as to produce the effect required.

Overhauling || Ovidius.

Overhauling is also vulgarly employed to signify an examination or inspection of the condition of a person or thing.

OVERRAKE, a nautical term. When a ship riding at anchor so overbeats herself into a high sea that she is washed by the waves breaking in upon her, then it is said that the waves overrake her.

OVERT, the same with open. Thus an overt act signifies an act which in law must be clearly proved; and such must be alleged in every indictment for high treason.

OVERTON, a town of Flintshire, in North Wales, in the hundred of Maylor, 183 miles from London and eight from Wrexham. It stands on the river Dee. In 1801 the population amounted to 1233, in 1811 to 1563, in 1821 to 1668, and in 1831 to 1746.

Overton, a town of the hundred of that name, in the division of Kingsclere, in the county of Hampshire, fifty-three miles from London. It was formerly a borough, and sent two members to parliament, but has long lost its charter. In 1801 the population amounted to 1130, in 1811 to 1178, in 1821 to 1341, and in 1831 to 1507.

OVERTURE, in *Music*, a piece of instrumental music which precedes an opera, a ballet of action, a cantata, &c. Amongst the finest modern overtures are Mozart's to "Il Flauto Magico," and to "Don Giovanni;" also some of Cherubini's and Beethoven's. Some of Rossini's, Weber's, and Spohr's have likewise great merit.

OVERYSSEL, one of the provinces of the kingdom of the Netherlands. It extends in east longitude from 5. 44. to 6. 59., and in north latitude from 52. 6. to 53. 52., and covers 1342 square miles. It is bounded on the north by Friesland and Drenthe, on the east by Hanover and Prussian Westphalia, on the south by Guelders, and on the west by Guelders and the Zuyder Zee. The face of the country is level, and the land sandy, a great part being covered with heaths, and other parts fertile land for grazing cattle, but marshy. The climate is foggy. This province is watered by the river Yssel and other smaller streams; and its productions are oats, buck-wheat, potatoes, apples, plums, flax, hemp, and turf for fuel. It breeds good horses. In 1831 the inhabitants amounted to 178,980, of whom 117,130 were Protestants, 59,360 Catholics, and the rest Jews. Zwolle is the capital.

OVIDIUS, P. Naso, one of the most celebrated of the Roman poets, was born at Sulmo, a city of the Peligni, on the 20th of March, B.C. 43., the very year in which Cicero lost his life. His father, who was of equestrian rank, bestowed on his son the best education that Rome could furnish, and this was afterwards improved by a residence at Athens. On his return to Rome he applied himself to law, and we find him in succession triumvir, centumvir, and decemvir. He soon found, however, that such a course of life did not suit his inclination; and withdrawing himself from active business, he devoted his whole time to the study of poetry. He was three times married; but his first two wives he divorced, and to his third, who was of the family of the Fabii, he was passionately attached. His daughter Perilla appears also to have been a favourite. With Virgil he could have been but little acquainted, as the Mantuan bard died when Ovid had scarcely attained his twenty-fifth year; but he was the intimate friend of Propertius, Catullus, and Cornelius Gallus. He passed many peaceful years in Rome, enjoying all the pleasures of a luxurious capital, and pursuing his favourite studies; but at last some of his proceedings having excited the displeasure of Augustus, he was ordered to retire from Rome, and take up his residence at Tomi, a city of the Getæ, situated near the mouth of the Danube. What really was the cause of his banishment is a point which has been much discussed by

Ovidius. the learned; but as the poet always speaks of it in dark and obscure terms, no satisfactory solution has as yet been suggested. It would appear to have been something of which he had been an innocent witness, and which he had been indiscreet enough to mention to his friends on some convivial occasion. As Julia, the niece of Augustus, was at this time banished on account of her shameless debaucheries, some have imagined that Ovid's punishment might have arisen from participation in her pleasures, or from some indiscreet disclosure of them. It has even been suggested that the lady whom he celebrates under the name of Corinna was no other than Julia; but this is impossible, as he himself states that he was only about his twentieth year when he sung her praises; and his banishment took place about his fiftieth year. Others have suggested that it arose from the disclosure of some state secret respecting Agrippa, the nephew of Augustus, who had been banished to Campania; but there is nothing in the works either of Ovid or of any ancient author that can enable us to come to any satisfactory conclusion. Ovid did not submit to the inconveniences of exile without murmuring, nor was he willing to allow himself to be forgotten. He showed that his mind was completely enervated by the luxurious life he had led at Rome; and he allowed himself to make the most abject entreaties to Augustus to procure his recall; but neither Augustus, nor after him Tiberius, would listen to his request. He remained at Tomi till the time of his death, which happened in the eighth year of his banishment, and the fifty-ninth of his age, A. D. 16.

Ovid's principal work is entitled *Metamorphoseon Libri*, probably from the Latin language not affording a word equally expressive of the author's meaning. They contain, in fifteen books, a series of about three hundred and fifty fables, which begin with Chaos, and end with the death of Cæsar; and they are so arranged that one fable seems to arise naturally from the other. The poet has shown much art in selecting those fables which were suited to his purpose, and in uniting into one consistent whole, materials which differ so much in form and in character. He has also contrived to throw into his work much dramatic spirit, which keeps up the attention of the reader, and gives a liveliness to every scene which he describes. No poet has succeeded better in painting the passions and affections which agitate the breast of man. The materials for his work are no doubt mainly drawn from the Greeks, and more particularly from the Alexandrine school, by which this subject had been frequently treated. He has borrowed much from Nicander, who also afforded materials for the work of Antoninus Liberalis, a Greek of the later ages. We possess a Greek translation of the Metamorphoses by Manuel Planudes.

His work entitled *Amorum Libri* consists of forty-nine elegies, and was originally divided, as he himself states, into five books; but he omitted two. The subject of these elegies is the poet himself and his love-adventures, which he describes with the utmost freedom and sincerity. The passions which moved him, and the feelings he experienced, are expressed with all the lightness of touch and grace so peculiar to the poet, and which has taken off much of the grossness that is natural to such a subject. According to a German critic, this work must have been published somewhere between 744 and 752 U. C. (B. C. 10–2).

His work entitled *Tristia*, in fifty elegies, and *Epistolæ ex Ponto*, forty-six elegies, in four books, were both composed at Tomi during his exile, the first between the years 762–765 (A. D. 9–12), and the second between 765–969 (A. D. 12–16). Both contain heavy and unceasing complaints of the unhappiness of his fate; but the constant repetition of the same idea produces a disagreeable effect; and the unmanliness of his grief does not tend to raise his character in the mind of the reader. The versification of these works, however, is perfect.

The *Heroïdes* are a series of love-letters written by heroines of the mythological age, to their absent lovers. Ovid does not appear to have borrowed the idea of this species of elegy from any Greek writer, though some have been inclined to suspect that such was the case. We possess twenty-one of these letters, but the genuineness of the last six has been doubted, some ascribing them to the pen of Aulus Sabinus. Love forms the subject of them all, with complaints of the absence of lovers; but the different circumstances in which each is placed have enabled the poet to throw much agreeable variety into the letters. The feelings are described with much truth; and though the simplicity of an earlier age is sometimes to be regretted, still they must be considered as one of the most successful of his works. Oviedo.

The *Fasti* is another work of very high merit, in which he describes the origin and customs observed in different Roman festivals, in chronological order. The six books which we possess include only the first six months of the year, though the poet intended to have completed in the same manner the circle of the year, but was prevented probably by his banishment. The subject is one which enabled him to display his historical and mythological learning; and as he seems to have taken much interest in the investigation of the ancient native religion of Italy, this poem is one of the chief sources from which we gather the customs and superstitions of those early times.

The bibliography of Ovid is immense; indeed the different editions of his works, together with the commentaries, and the translations, would fill a volume. We shall here confine ourselves to the citation of the principal editions. These are, 1. The Bologna edition, Azzoguidi, 1471, in folio, being the first book printed at Bologna; 2. That of Rome, Conrad Sweynheym and Arnold Pannartz, 1471, in two volumes folio, published under the auspices of the Bishop of Alenia; 3. Those published by the Alduses, at Venice, about the beginning of the sixteenth century, which are greatly esteemed, particularly that of 1502, 1503, in three vols. 8vo, and that of 1515, 1516, also in three vols. 8vo, with notes by Navagero; 4. The Leyden edition, 1661, 1662, in three vols. 8vo, *cum notis variorum*, brought out under the superintendence of Cnipping; and, 5. That of Amsterdam, 1727, in four vols. 4to, being the beautiful edition of Burmann. The French translations are exceedingly numerous, and, upon the whole, the best that have appeared in any modern language.

OVIEDO, a city of Spain, in the province of Asturias, of which it is the capital. It is situated between the rivers Nalon and Nora, on a hill of granite, and enjoys a serene atmosphere, although generally rather rainy. Its fields are fertile, and yield abundance of fruits and horticultural vegetables; and near it there are good meadows, where cattle are depastured, and hay made for the winter consumption of stock. The city contains a population of 6000 inhabitants, amongst whom there are some of the most distinguished families of the province, who unfortunately prefer a residence in cities to living on their own estates. It is not a place of trade, but rather the resort of lawyers and clergy. It has a very magnificent cathedral in the Gothic style, with a remarkable lofty tower, an university, a well-endowed hospital, and a beautiful public walk. It is supplied with water by a fine aqueduct, which conveys it from two fountains in the neighbouring hills. Long. 5. 56. 22. W. Lat. 43. 21. 55. N.

OVIEDO, *John Gonsales*, in Spanish, Gonçalo Hermandez de Oviedo y Valdez, a celebrated historian, was born at Madrid about the year 1478, and educated amongst the pages of Ferdinand and Isabella. Oviedo had attained the age of fifteen when Christopher Columbus returned from his first voyage; and being seized with a strong desire to learn the details relating to the great discovery of the il-

Oviedo. lustrious navigator, he soon made himself acquainted with all that had passed in this wonderful expedition. Having embraced the profession of arms, he distinguished himself in the war of Naples, where he rendered important service to Spain; and it was in recompense of his talents and bravery that Ferdinand appointed him director of the gold and silver mines in the island of Haïti, which Columbus named first *Española*, and then *San-Domingo*. Oviedo proceeded to his destination in 1513; and employed in working the mines, which were poor compared with those afterwards discovered in the continent of America, the natives of the island, a good and gentle race, naturally indolent, and by no means robust, with constitutions already enfeebled by the ravages of syphilis, a disease previously unknown in the old world. This unfortunate people, who had received the companions of Columbus with so much cordiality, Oviedo treated worse than beasts of burden; compelling them to labour without intermission, and exercising the greatest cruelties to enforce submission to his commands on the part of a race which had previously lived in idleness, subsisting on the abundant natural productions of the climate, and on fish, which they caught without difficulty, as an amusement rather than an occupation. The abominable tyranny to which the natives were thus subjected soon caused a considerable diminution of their number; and Oviedo, in order to justify himself for the oppression and cruelty which he exercised, had the bad faith to allege, in his writings, that the Haïtians were dissolute, unprincipled, and in every respect deserving of extermination. Nor was this all. Not content with calumniating the people he had so cruelly treated, he added the ridiculous falsehood, that amongst them syphilis was the result of debauchery; whereas, according to the testimony of all impartial historians, it had been ascertained by Columbus that the Haïtian people were comparatively indifferent to sexual pleasure, a circumstance by no means common in a burning climate, and which can only be explained by the weak physical organization of these islanders, or by a deficiency of vital power. A residence of nearly twelve years in Haïti enabled Oviedo to study the natural history of the island in all its parts, to observe syphilis in all its types, and to ascertain the remedies which the natives employed in their treatment of the disease. The principal of these was the gaïac, which is still classed amongst the number of the antisyphilitics. On his return to Spain in 1525, Oviedo published a journal of his researches under the title of *Summario de la Historia General y Natural de las Indias Occidentales*, Toledo, one vol. folio, dedicated to Charles V. At a later period, however, the author recast this production, to which he added numerous facts connected with the natural history of Haïti, and, in 1535, he published the first twenty books of his great work entitled *La Historia General y Natural de las Indias Occidentales;* but the entire work, which is divided into fifty books, did not appear till 1783, when it came out under the auspices of the Marquis of Truxillo. Oviedo affirms, in his narrative, that the syphilis is an endemic malady in the island of Haïti, and that having been contracted there by the Spaniards belonging to the expedition of Columbus, it was by them communicated to the Neapolitans belonging to the expedition of Gonçalvo de Cordova; and, in point of fact, the syphilis appeared at Naples immediately after the return of the squadron of Gonçalvo. Several writers, who pretend that syphilis existed in Europe anterior to the discovery of the new world, have attempted to prove this hypothetical assertion from the writings of Oviedo himself; but these, so far from countenancing any such notion, contain incontestible proof of the error into which those persons have fallen who ascribe the origin of this fearful scourge to the old continent. Some authors assure us that Oviedo, having been infected by syphilis during his sojourn at Naples about the year 1513, came to the conclusion that it had been imported from Haïti; and conceiving that there must exist in that island a remedy for the disease, solicited the employment which led him thither, and in fact discovered that the wood of gaïac was the infallible antidote employed by the natives, and by which also he effected his own cure. It is added that, on his return to Spain, Oviedo commenced physician for syphilitic maladies, in the treatment of which he made use of the wood of gaïac, with a success which considerably augmented the fortune he had acquired in working the mines of Haïti, at the expense of the lives of a great number of the natives. (A.)

Ovilia || Owen.

OVILIA, or Septa, in ancient Rome, a place in the Campus Martius, at first railed in like a sheep-pen, but afterwards adorned with marble, and beautified with walks, galleries, and a tribunal or seat of justice. Within this precinct or enclosure the people were called to give their suffrages for the election of magistrates. The ascent into the ovilia was not by stairs, but by *pontes*, or narrow boards, laid there for the occasion. On this account, *de ponte dejici* signified to be deprived of the privilege of voting; and persons thus dealt with were called *depontani*.

OVIPAROUS, a term applied to such animals as bring forth their young from eggs; as birds, insects, and others.

OVOLO, or Ovum, in *Architecture*, a round moulding, the profile or sweep of which, in the Ionic and Composite capitals, is usually a quadrant of a circle; and hence it is also commonly called the *quarter-round*. It is usually cut with representations of eggs and arrow-heads or anchors placed alternately.

OWEN, Dr John, an eminent and learned dissenting minister, was born in 1616, at Hadham, in Oxfordshire, of which place his father was vicar. He made such surprising proficiency in learning, that at twelve years of age he was admitted into Queen's College, Oxford; and in 1635 he was made master of arts. Having disapproved of the new regulations introduced by Archbishop Laud, the chancellor, he refused to comply with them, and in 1637 was obliged to leave the university. When he took orders he became chaplain to Sir Robert Dormer of Ascot, in Oxfordshire, and was at the same time tutor to his eldest son. He was afterwards chaplain to John Lord Lovelace of Hurley, in Berkshire. When the civil war broke out, he openly espoused the cause of the parliament; which was so resented by an uncle who had intended to leave him his estate, that he discarded him, and left it to another. Yet though Lord Lovelace joined the king, he treated his chaplain with great civility; but on his taking the field with the royal army, Mr Owen went to London, and soon afterwards joined the nonconformists. In the year 1642 he published his book entitled a Display of Arminianism, which laid the foundation of his future advancement. The committee for purging the church of scandalous ministers were so pleased with this work, that Mr White, their chairman, sent him a presentation to the living of Fordham in Essex; but after he had been there about a year and a half, the patron, hearing that the sequestered incumbent was dead, presented another to the living, upon which the Earl of Warwick gave Mr Owen the living of Coggeshal. He had not, however, been long at that town before he left the Presbyterians, and, joining the Independents, formed a church there. He was sent for several times to preach before the parliament, particularly on the 28th of February 1648–49, the day of humiliation for the intended expedition to Ireland. Cromwell, who was present at this last discourse, and had never heard him before, was so extremely pleased with it that he desired the preacher to accompany him into Ireland, at the same time offering to provide him with a residence in the College of Dublin. Mr Owen accepted the offer, but returned in about half a year. Soon afterwards Cromwell sent him into Scotland,

Owhyhee ‖ Oxford.

but he also returned from thence after about half a year's residence at Edinburgh. He was then promoted to the deanery of Christ-Church, Oxford, whither he went in 1651; and Cromwell, being now chancellor of the university, nominated him his vice-chancellor. The next year he was created doctor of divinity by diploma. Dr Owen held the post of vice-chancellor five years, during which he behaved with the greatest moderation; for, although often solicited, he never molested the meeting of the royalists at the house of Dr Willis the physician, where divine service was performed according to the liturgy of the Church of England; and though he was a commissioner for ejecting scandalous ministers, he frequently overruled his brethren in favour of those royalists who were distinguished by their merit. At the death of Cromwell he was removed from the vice-chancellorship; and at the Restoration he was ejected from his deanery of Christ-Church. But he had provided himself a comfortable retreat at an estate he had purchased at Hadham. He now employed himself in preaching as often as he had an opportunity, and in writing books; one of which, entitled *Fiat Lux*, falling into the hands of Lord Clarendon, he was so pleased with it, or from policy pretended to be so, that he sent for Dr Owen, and acknowledging the service he had done by it to the Protestant religion, offered to prefer him in the church if he would conform; but he respectfully desired to be excused. His moderation secured him respect from persons of opposite principles; and in the number of his friends were Dr Wilkins, bishop of Chester, and Dr Barlow, bishop of London. He died at Ealing in 1683. His works are printed in seven volumes folio.

OWHYHEE, the easternmost, and by far the largest, of the Sandwich Islands. See the article POLYNESIA.

OWLAH, a city of Hindustan, in the province of Delhi and district of Bareilly. It is pleasantly situated on the western bank of the Harowly River, and, with the adjoining district, came into the possession of the British in 1802. It is an ancient town, and was fixed upon in the early part of the last century by Aly Mohammed, one of the Rohilla chiefs, as the capital of his territories. On his death Owlah fell to the share of Futteh Khan, superintendent of the household, and after the death of the latter his son Ahmed Khan resided there. It was also the residence of many of the chiefs and their families, which conduced greatly to its grandeur and extent. But on the cruel extermination of the Rohilla nation by Sujah ud Dowlah, aided by the British, in 1774, it was forsaken by its principal inhabitants; and it has now fallen into decay and ruin. It is about sixteen miles north-west from the town of Bareilly. Long. 79. 35. E. Lat. 28. 10. N.

OWLING, so called from its being usually carried on in the night, is the offence of transporting wool or sheep out of this kingdom, to the detriment of one of its staple manufactures.

OWRAM, NORTH, a township in the parish of Halifax, in the west riding of Yorkshire, 197 miles from London, where the inhabitants are chiefly employed in making woollen goods. In 1801 the population amounted to 4887, in 1811 to 5306, in 1821 to 6841, and in 1831 to 10,184.

OWRAM, *South*, a township in the parish of Halifax, only half a mile distant from North Outram, and, like it, chiefly occupied in the woollen manufacture. In 1801 the population amounted to 3148, in 1811 to 3615, in 1821 to 4256, and in 1831 to 5751.

OXFORD, the capital of the English county of the same name, is situated at the junction of the river Cherwell with the Isis, which about eight miles lower down receives the waters of the Thame, and then becomes the Thames, a contraction of Thame-Isis. It is fifty-five miles from London by the High Wycombe road, and fifty-eight by Henley. It is pleasantly situated on ground rising gently from the rivers which almost surround it, and its immediate vicinity smiles with fertile and verdant meadows; beyond which, on the east, south, and west sides, it is bounded by an amphitheatre of hills, and on the north the view is extended over a rich district in the highest state of cultivation. The air is pure and salubrious; and from the neighbouring heights, the city, with its spires, and domes, and towers, presents an impressive spectacle of all that is lovely in nature, magnificent in art, and sacred in antiquity. Oxford.

The locality of Oxford is favourable for intercourse with the whole of the kingdom. It is nearly in the centre of England; and good lines of road pass through it from almost every quarter. Its vicinity supplies most of the first necessaries of life with facility; and though formerly the enormous price of fuel was the subject of serious complaint, that evil has been remedied by a canal which joins the Grand Junction Canal at Braunston, in Northamptonshire, and has proved a great advantage to the city, by conveying the coals of Staffordshire at a cheap rate, whilst the capital expended in the undertaking has become a very lucrative investment to those who embarked money in the project. Besides the canal, Oxford has water communication by the river Thames with both sides of the kingdom. The Thames and Severn Canal unites these two rivers through the Stroud Canal, and thus goods may be conveyed downwards to Oxford from Bristol, Gloucester, Worcester, and Birmingham, and upwards from the mouth of the Thames near the metropolis of the empire.

The city, properly so called, was formerly surrounded by walls, considerable portions of which still remain. It is of an oval form, and about two miles in circumference. The municipal limits, which are now made co-extensive with the parliamentary boundary, comprehends the whole or part of twenty parishes, the extreme extent of the borough each way being now about three miles. Four principal streets, broad and well built, cross each other at the centre; but the communications between these streets are rather narrow. The High Street is generally admired, as well for its length as for the number and the magnificence of the buildings on both sides of it; the effect of which is much heightened by its curvature, which at every advance opens up new views of architectural grandeur. In this street is the entrance to the market, which is well stored with provisions of every kind, equal in quality to any in the kingdom. The town-hall is a fine building, serving the purpose which its name expresses, as well as that of a county-hall; and the assizes, the county-sessions, the election for city and county members, as well as public meetings, are held in it. It was built in 1754, at the expense of Mr Rowney, then member for the city; but has been since considerably improved by the united funds of the county and the city. It is one hundred and thirty-five feet in length by thirty-two feet in breadth, and is the apartment in which, in the year 1814, the freedom of the city was presented to George IV., the emperor of Russia, the king of Prussia, and many other distinguished personages. Adjoining to this edifice is the council-chamber, for meetings of the city council, which is adorned with portraits of eminent persons and benefactors. The corporation now consists of a mayor, ten aldermen, and twenty-nine councillors, with a recorder, and justices of the peace appointed by the crown. The city returns two members to the House of Commons. These, before the Reform Act, were elected by the freemen; but the ten-pound householders are now added to them. Oxford is a county of itself. The county-jail, a large building, was erected upon the site of the ancient castle about thirty years ago; but, besides the county-jail, there is a city prison and a bridewell. The remains of the original tower of the fortress, and a large magazine for storing provisions for the garrison, are still preserved.

Oxford.

Some have pretended to trace the origin of Oxford to remote antiquity; but their speculations can only be looked upon as fanciful conjectures. No credit can be given to any statement respecting it previous to the reign of Alfred. In 727, a monastery was founded at Oxford, or, as it was originally called, Oxenford, dedicated to the Holy Trinity. The habitations of the laity attracted to the neighbourhood were probably the origin of the town; and as the clergy, previous to the Conquest, were the sole depositories of learning, and the only teachers to whom the people could look for instruction, and as every monastery became more or less a kind of school, it is not improbable that the educational department of the monastery was the germ of the University of Oxford.

In the course of thirty years, between 979 and 1009, the town was thrice consumed by fire; and during the contests between the Danes and Saxons, it often suffered severely. It was the occasional residence of King Edmund, surnamed Ironside, who was murdered there; of Canute the Great, who repeatedly held parliaments in it; and of Harold, surnamed Harefoot, who was crowned and died in Oxford.

The inhabitants having refused to open their gates to William the Conqueror, he obtained entrance by force, and levied a heavy tax on the townsmen as a punishment for their resistance; and the better to restrain their rebellious spirit, he built and fortified a strong castle on the west side of the town, near the river.

The successors of the Conqueror frequently made Oxford the place of their residence, and several of them were munificent patrons of its schools. In the contest between King Stephen and the Empress Maud, the latter, having taken shelter in the castle, was besieged in it by the king in person, and only escaped by stratagem the day before it surrendered.

In 1177, the princes and chief lords of Wales did homage here for their territories and estates to Henry II. This monarch resided, during a great part of his reign, in the palace of Beaumont, which was built in the north suburbs by Henry I. In this palace Richard Cœur-de-Lion was born; and here King John passed many of his troubled hours. Richard I. was a great promoter of learning, and gave especial encouragement to Oxford, which was the place of his birth. Many new halls or schools were established under his patronage, and by means of funds furnished from his private exchequer. To such a pitch had he raised the reputation of Oxford, that in the succeeding reign its schools were attended by not less than three thousand students; but in the year 1209 this prosperity was sadly overcast, and the town, as a seat of education, threatened with total destruction. A student, whilst engaged in some manual exercise, accidentally killed a woman belonging to the town, and, being alarmed for the consequences, took to flight. The mayor and burgesses surrounded the hall to which the supposed murderer belonged, and demanded that he should be delivered up. They were informed that the accused student had fled; but this answer by no means appeased the clamours of the multitude, who seized three students, entirely unconnected with the affair, and hanged them without trial or inquiry. The teachers and scholars, justly enraged at this barbarous outrage, unanimously quitted Oxford, and betook themselves to Cambridge and other places; and they did not return till the humbled inhabitants had repeatedly applied for pardon, and expressed the deepest contrition for their conduct.

In the reign of Henry VIII. Oxford was elevated to the rank of a city, and that of a bishop's see; and it was at Oxford that Archbishop Cranmer, and Bishops Ridley and Latimer, were executed as heretics, by order of Queen Mary, in October 1555.

In the year 1577, the plague raged with dreadful mortality in the town. During the trial of a popish bookseller, accused of circulating mischievous pamphlets, nearly all the persons present were suddenly seized with sickness; and within forty hours upwards of three hundred died, amongst whom were the chief baron, the high sheriff, several justices of the peace, and most of the jurors. When the plague broke out in London, King James withdrew to this city for safety; but the dreadful scourge visited Oxford not long afterwards, and made such awful devastation that the scholars fled from the University, and the citizens shut up their shops; and not a living creature, besides nurses and corpse-bearers, was to be seen in the streets, which were covered with grass, even in the market-place.

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During the struggles between Charles I. and his parliament, the king, in consequence of the disaffection of the citizens of London, removed his court to Oxford; being well assured of the loyalty of the townsmen, and the inviolable allegiance of the university. The melancholy winter of the year 1646 was spent by the unfortunate monarch within the walls of Christ-Church; where he assembled a parliament of his diminished and disheartened adherents, and where he wrote his memorable letter to Lord Digby, in which he declared, "if I cannot live as a king, I will die as a gentleman." Though the city was strongly fortified, and considered as a post of great importance by both parties, it never happened, during the war, to be the scene of any great military transaction; but the negotiations for peace between Charles and the republican party were chiefly carried on at Oxford.

The last parliament which met in this city was convened by Charles II. in 1681, and lasted only seven days. The party spirit and turbulence displayed, not only by the populace, but by the representatives, compelled the king to order its premature dissolution, to prevent the passing of a bill for banishing and excluding from the throne his brother, the Duke of York, afterwards James II.

Oxford has the transcendent glory of being the cradle of the Reformation. Wickliffe, whose name will be venerated by all who value the truths of Christianity, and the progress of the human mind, was warden of Canterbury College; and it was here that he read those lectures on divinity which shook to its foundation that spiritual despotism which held Europe in thraldom, and here he first inculcated those truths which form the basis of religious liberty.

The University contains twenty colleges and five halls.

Merton College, the oldest in point of legal establishment, was founded by Walter de Merton, bishop of Rochester, who established it by charter, dated 7th January 1264. It consists of three courts. The chapel, which is situated at the west end of the outer court, is a fine specimen of old English architecture. The tower and gate of the outer court were constructed in the early part of the fifteenth century; and the whole of the other part was rebuilt in 1589. The second, or large inner court, exhibits a mixed style of architecture; the third, or small court, is the oldest, and is supposed to have been built at the same time with the library, which forms its south and west sides. This is the oldest library in the University, and possesses many valuable manuscripts and early printed books. In the hall of this college Queen Elizabeth was entertained at dinner on her visit to the University in 1592.

University College is said to have owed its origin to King Alfred; but it is ascertained that it was founded by the University, with funds left by William of Durham, in 1249. It stands on the south side of the High Street, and consists of two quadrangular courts, which were built at various times between the years 1634 and 1675.

Baliol College was projected by John de Baliol, father

Oxford. of the unfortunate king of Scotland, in 1263; but, in consequence of his sudden death, it was only founded in 1282, by his widow, Dervorguilla. The architecture is very irregular; none of the present buildings are of earlier date than the fifteenth, and the east and south-east sides were rebuilt in the beginning of the eighteenth century. The court of the quadrangle is one hundred and twenty feet by eighty; there is also belonging to the college an area on the north-west, containing lodgings for the students, and a new building fronting the street one hundred and eight feet in length.

Exeter College was founded in 1315, by Walter de Stapleton, bishop of Exeter. It has been built at various times, and forms one extensive quadrangle, nearly a hundred and thirty-five feet square. The architecture of this College is of an uniform and simple character. The whole of the west front has recently been renewed with Bath stone, and a handsome new building erected, facing Broad Street.

Oriel College was founded in 1326, by Adam de Brom; and shortly after was taken under the protection of Edward II. It consists of a quadrangular range of buildings, with two ranges on the east and west sides of the garden, between which is the library, an elegant modern building, from a design by Wyatt.

Queen's College was founded by Robert de Eglesfeld, and obtained a charter from Edward III., dated the 18th January 1340. The present buildings are of modern erection; they consist of two courts, divided by the hall and chapel, in an oblong form, three hundred feet in length by two hundred and twenty in breadth. The library, which contains about 18,000 volumes, is a magnificent room, a hundred and twenty-three feet by thirty.

New College. The foundation-stone of this college was laid by William of Wykeham, for his scholars of Winchester College, in the year 1380; but the buildings were not completed till 1386. As originally projected by the founder, they consist of a spacious quadrangle, including the chapel, hall, and library. A range of cloisters, extending a hundred and forty-six feet by a hundred and five, with the area within, were consecrated in 1400, as a burial-place for the college. The chapel is one of the finest buildings in the University, and is exceedingly beautiful and chaste in its interior decorations.

Lincoln College was founded by Richard Fleming, bishop of Lincoln, in 1427, and completed by Bishop Rotherham. The chief buildings compose two quadrangular courts. The larger, which contains the library and hall, was built soon after the founder's death; but the smaller, in which is situated the chapel, whose old painted glass windows are the finest in Oxford, was not built till two centuries afterwards.

All-Souls College was founded in 1437, by Archbishop Chicele. It consists of two spacious courts, the one opening into the High Street, and the other into the court where the Radcliffe Library is situated. The latter quadrangle, which was erected in the beginning of last century, is a hundred and seventy-two feet in length by a hundred and fifty-five in breadth; the buildings are in the mixed Gothic style of architecture, and very handsome. On the south side is a beautiful chapel, with an altar-piece by Raphael Mengs. The library, which is on the south side, is a hundred and ninety-eight feet in length by thirty-two and a quarter in breadth, and forty feet in height, and contains above 110,000 volumes.

Magdalene College was founded by William of Waynflete, bishop of Winchester, under a license dated the 18th July 1457. It is situated on the east side of the city, near the Cherwell, and is one of the finest ranges of buildings in the University. On the side fronting the High Street there is a finely-proportioned tower, a hundred and forty-five feet in height. The chapel is a beautiful Gothic structure, which has recently been restored, in good taste. Magdalene College being bound by its statute to entertain the kings of England and their sons when at Oxford, it has frequently been the scene of royal festivity. Edward IV. and Richard III. were both entertained here by the founder. Prince Arthur paid a visit to this college in 1496; and in 1605 James I. held his court within its walls, on which occasion Henry prince of Wales was admitted a member of the society. In 1649, Oliver Cromwell, Fairfax, and other officers of the parliamentary army, had a sumptuous dinner provided for them here, and afterwards played at bowls in the college green. Oxford.

Brazen-Nose College was founded by William Smyth, bishop of Lincoln, in concert with his friend Sir Richard Sutton. The buildings were begun in 1509, and occupied the site of several halls, amongst which was Brazen-Nose Hall, whence the new foundation derived its name. It consists of an extensive quadrangle, a smaller court on the south, a range of buildings called the New Buildings, and the principal's lodgings. The front of this college forms the west side of Radcliffe Square.

Corpus Christi College was founded and endowed in the year 1516, by Richard Fox, bishop of Winchester. The building, which stands to the east of Christ-Church, originally consisted of one large quadrangle, with a chapel, hall, and library; but various additions have since been made. The altar-piece in the chapel is the Nativity by Rubens. The library contains some curious printed books and manuscripts.

Christ-Church College is indebted for its origin to the munificence of Cardinal Wolsey, who commenced it in 1524, under the designation of Cardinal College, upon a scale of magnificence far surpassing that of any of the other founders; but upon his disgrace Henry VIII. seized the revenues. In 1532 Henry was induced to grant the college a charter, and directed that it should be called King Henry VIII.'s College; but about twelve or thirteen years afterwards Henry converted the college into a cathedral church, translating to Oxford the episcopal see of Oseney; and thus it became an ecclesiastical endowment, with a foundation for children annexed to it. Besides the cathedral, the buildings consist of two spacious quadrangles, with two smaller courts; and in the tower, which rises from the gateway in the centre of the principal front, is suspended the bell called "Great Tom." The cathedral is supposed to have been completed about 1180, but parts of it are of much earlier date. The hall built by Wolsey, with its roof of richly carved oak, ornamented with the armorial bearings of Wolsey and Henry VIII., is a fine specimen of his magnificent taste.

Trinity College was founded in 1554, by Sir Thomas Pope, who purchased for this purpose the extensive buildings of Durham College. This college formerly consisted chiefly of a low quadrangle, with hall, library, and chapel. In 1664, extensive additions were made, and soon afterwards a new court of three sides was built by Sir Christopher Wren.

St John's College was founded and endowed in 1557, by Sir Thomas White, a citizen and merchant of London. It consists of two quadrangles, and has in front a wide terrace and a row of lofty elms. The inner court was built in 1635, from a design by Inigo Jones.

Jesus College owes its foundation to Dr Hugh ap Rice, or Price. Queen Elizabeth instituted the establishment by charter, dated the 27th June 1571; but though nominally foundress, she bestowed little patronage, and still less property, on the college, the funds having been supplied by Dr Price and the munificence of other individuals. The buildings form two quadrangles, the first measuring ninety feet by seventy, and the second a hundred by ninety. The front towards the street was rebuilt in 1756.

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Wadham College was projected by Nicholas Wadham; but dying before his plan could be put in execution, his widow founded it in 1613. It consists of one quadrangle about a hundred and thirty feet square. The hall is one of the largest in the University. The Royal Society originated in this college, and its meetings were held in a room over the gateway, from 1652 to 1659.

Pembroke College. Though in the charter, which is dated 1624, King James is called founder, and the Earl of Pembroke the chancellor of the University, yet they contributed little or nothing towards the establishment of this college; the real founders were Thomas Tesdale and Richard Wightwick. It consists of a small neat quadrangle; and the chapel attached to it, which was erected in 1728, is an elegant building of the Ionic order.

Worcester College was founded in 1714, under the will of Sir Thomas Cooks. It is situated upon the western side of the city, near the banks of the Isis. It consists of a range of buildings, having the library, hall, and chapel in the centre, an elegant line of new buildings on the north, and the old buildings on the south side.

Hertford College, anciently Hart Hall, was elevated to the rank of an independent college in the year 1740; but since 1805 no principal could be elected, owing to the nature of the statutes. It has now ceased to exist as a college. The site is occupied, under an act of parliament passed in 1816, by St Mary Magdalene Hall.

The halls were originally the private property of inhabitants of the town, who let them for the use of the students; but after the endowment of colleges, the halls gradually fell into disuse. Five, however, still remain, and the students who belong to them wear the same dress, and have the same university privileges, as the other students; but the halls have no fellowships or scholarships, and whatever property they possess is held in trust by the University. The names of the halls are St Mary's, Magdalene, New Inn, St Alban's, and St Edmund's. There is nothing in their architecture worthy of remark.

The Bodleian, or Public Library, was founded by Sir Thomas Bodley, at the close of the sixteenth century, on the remains of that which was originally established by the Duke of Gloucester. The erection of the present building was begun in 1610. The principal room is in the form of the letter H. The Bodleian is one of the five libraries which, according to act of parliament, receives a copy of every newly-published book. The continual accessions which it has received have rendered it one of the best libraries in Europe. The library is open between Ladyday and Michaelmas from nine in the morning till four in the afternoon, and between Michaelmas and Ladyday from ten in the morning till three in the afternoon. No book can be taken out of the library; and from the illiberal nature of the regulations, it is of little use, even to the resident members of the University. The Arundel Marbles are placed in an apartment on the north side of the schools.

The Radcliffe Library is one of the most imposing architectural ornaments of the University. It was founded by Dr Radcliffe, who bequeathed L.40,000 for its erection; and the building was executed by Gibbs between the years 1737 and 1749.

The Clarendon Printing-house was erected in 1711, from the profits arising out of the sale of Lord Clarendon's History of the Rebellion, the copyright of which was presented to the university by his lordship's son. It is a massive structure, two stories high. The business of printing for the university was carried on in this building till 1830, when it was removed to the present printing-house, which was commenced in 1826, and ready for use in the following year.

The Theatre was built by Gilbert Sheldon, archbishop of Canterbury, and chancellor of the University in 1669, on the plan of the Theatre of Marcellus at Rome; and the architect was Sir Christopher Wren. It is used for public meetings, for the recital of prize compositions, and occasionally for conferring degrees.

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A museum was founded in 1682, by Elias Ashmole. At the extremity of the northern suburbs stands the Observatory; and at the entrance of the city by the London road are the Physic Gardens, which were commenced in 1622 by the Earl of Derby.

When Henry VIII. elevated Oxford to the rank of a bishop's see, he converted the ancient church of St Frideswide into the cathedral. It is built in the form of a cross, with a spire in the middle; and the tower contains ten bells, which formerly belonged to Oseney Abbey. The length of the chapel from east to west is a hundred and fifty-four feet. The nave was originally almost double its present length, but was in part taken down by Cardinal Wolsey, to make room for the dwellings of the canons. The length of the transept from north to south is a hundred and two feet. The height of the western part is forty-one feet, and of the choir thirty-seven feet. This building contains monuments of great antiquity. Most of the windows were destroyed in 1651; those that remain, with others since executed, display some historical scenes connected with sacred subjects. It has of late years been thoroughly repaired, and has recently been adorned by a fine statue of Dr Cyril Jackson, long president of the college. It was executed by Chantrey, and is universally allowed to be an admirable likeness.

In noticing the parochial churches of the city, the first to be mentioned is that of St Mary, which, though the public service is partly conducted under the direction of the University, and it is hence called the University Church, does in fact belong to the vicar and the inhabitants of the parish. It is a spacious Gothic structure, finished in the year 1498. The lofty spire, a hundred and eighty feet in height, is a conspicuous object, and the tower contains six large and well-toned bells. In 1828 it was repaired and very highly finished, but in harmony with the original plan.

There are thirteen other parish churches. St Peter's-in-the-East is an interesting edifice, of a very ancient date; and is supposed to have been originally built by St Grymbald, under the patronage of Alfred. St Michael's is of equal dimensions with St Mary Magdalene's, and is said to have belonged to the canons of St Frideswide, before the Norman conquest. The windows are large and pointed. St Martin's, or, as it is more commonly called, Carfax, is the church of the city, at which the mayor and corporation attend divine service. It has been rebuilt within the last fifteen years, upon the site of a structure of great antiquity, and much enlarged. St Peter's-in-the-Bailey, at the west end of the city, was opened for divine service in 1740, and a gallery added to it thirteen years after, at the expense of an individual named Flexney. It is seventy feet in length and thirty-eight in breadth, with a tower containing only two bells. St Aldate's, of great antiquity, is said to have been founded or restored in 1004. It is a venerable pile, consisting of a nave, two aisles, and a chancel, and is about a hundred feet in length. St Ebbe's is a plain, modern church, built in 1817. The church of St Mary Magdalene is a neat stone edifice, eighty-eight feet in length, said to have been founded in 1194, and is remarkable for three uniform pointed windows in a chantry chapel within it, and a parapet of open trefoil work of great beauty. St Giles is an edifice venerable from its age, being furnished with numerous lancet-shaped windows. It is a solid and capacious building, though not sufficiently so for the population of the parish, which has rapidly increased. Holywell Church, so named from a well of great sanctity in ancient times, and near to it, is a small building, with a tower

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said to have been built in 1464; but the church itself is much more ancient. It has an embattled tower, containing six bells. St Clement's, in the eastern suburb, is a handsome edifice, lately enlarged, owing to the great increase of inhabitants. St Thomas's Church, at the western extremity of the city, was founded by the canons of Oseney in 1141. It is about a hundred feet in length, and has lately been much improved. The church or chapel of St John is also the chapel of Merton College; but the parishioners have a part of the north side allotted to them as the place of sepulture, the chaplain of the college reading the burial service. There is also the church of All Saints, in the High Street. Besides these parish churches, there are four places of worship for Protestant dissenters and Wesleyans, and a small but neat chapel for the Roman Catholics. The population amounted in 1801 to 10,534, in 1811 to 11,916, in 1821 to 14,901, in 1831 to 18,436, and in 1833 to 20,411. This does not include those persons resident in the several public buildings comprehended in the University, or in the House of Industry, or the Radcliffe Infirmary. The census is taken at a period of the year when the colleges are not at the fullest, and the absent students, fellows, and professors, are consequently included in the enumerations of other districts. The whole number residing in the university amounted in 1801 to 1171, in 1811 to 1015, in 1821 to 1463, and in 1831 to 1634. The residents in the House of Industry were 219, and those in the Radcliffe Infirmary 145; thus making the whole population at the census of 1831 to be 22,186. The system of education taught in the colleges will be treated of under the article UNIVERSITIES.

OXFORDSHIRE, an inland county of England, chiefly celebrated on account of its capital, which is one of the principal seats of learning in the British dominions, and from which city it has derived its name. It is bounded on the east by Buckinghamshire; on the south, south-west, and south-east by Berkshire; on the north-east by Northamptonshire; and on the north-west by the county of Warwick. The river Thames (called sometimes the Isis till it reaches Oxford) is the line of demarcation on the whole of its southern boundary; running between this county and Berkshire with various, and, in the latter part of its course, most beautiful sinuosities. The county is of a most irregular figure. Near the centre, in which the city of Oxford stands, it is not more than seven miles in breadth, and at no great distance to the north it is thirty-eight miles. Towards the north it resembles a cone, and to the south it is similarly contracted. Its extreme length is fifty miles. The extent is estimated at 742 square miles, or 474,880 English acres. It contains one city, twelve market-towns, and 207 parishes, and is divided into fourteen hundreds.

This county is by no means uniformly beautiful. On the north, the absence of hedges, which are supplied by stone walls, gives a dreary appearance to the face of the country. In the centre it is generally flat and woody, affording few pleasant prospects, though its trees and verdure give it the semblance of wealth. The southern part, from the beauty of its rivers, the gentle swelling of its hills, the verdant meadows between them, and the number of highly embellished residences of rich proprietors, is a district abounding with rural charms. The Chiltern Hills, the highest range in England south of the river Trent, belong to this portion. They are in many parts adorned with beech-woods, and in every interval of these woods cultivated quite to their summits.

The climate of the county varies according to the elevation and exposure. In the north, where no hedges impede the winter winds, the cold is somewhat severe; and the Chiltern Hills are frequently enveloped in damp fogs, especially in the more woody parts of them. Mr Arthur Young, in his Agricultural Survey of Oxfordshire, has formed a classification of the soils in the different districts of the county, which, like all similar estimates, must be received with hesitation, or at least with many exceptions. The red soil, found chiefly in the north, and by far the most fertile, he estimates at 79,635 acres. The land, provincially called *stone-brash*, found in the centre, and the surface of which is often covered with stones, amounts to 164,023 acres. The Chiltern lands, the soil of which is a loam resting everywhere on a bed of chalk, and covered with flint stones, are 64,778 acres. To these are added 166,400 acres under the description of miscellaneous, which comprehends all sorts of soil, from loose sand to the heaviest clay, and includes the rich meadows on the banks of the rivers.

Although this is wholly an agricultural county, and although much progress in improvement has been made of late years, yet the general practices are by no means equal to the average of those of the rest of England. The most beneficial husbandry is founded upon the valuable water-meadows on the banks of the different streams. These are naturally so fertile that they appear to have prevented that care which would render them still more productive. Little attention is paid to draining, and still less to irrigation; though the good effects of both these practices are obvious, and their accomplishment easy in many circumstances. Some few oxen are fattened, and butter and cheese made in the dairies, but the facility of navigation induces the farmers to make more hay than is consumed by their stock, and to send it to distant and higher markets than their own, nearer to the metropolis. On the arable fields, especially on the stony lands near Burford, the use of oxen for the plough is very common; and the Herefordshire breed is generally preferred for that purpose. The practice of paring and burning the surface prevails in many parts of the county; and in the newly enclosed lands the application of lime as a manure is highly beneficial; whilst on the Chiltern lands it is not found to produce a good effect equal to the expense which attends it.

Where the soils are so very various, the rotation of crops must necessarily vary with them. On the red soils, the most usual course is, 1st, turnips; 2d, barley, or spring-wheat; 3d, clover; 4th, wheat; 5th, peas or beans; and, 6th, oats. On the stone-brash lands, the usual rotation is, 1st, turnips; 2d, barley; 3d, clover, to stand for two years; 4th, wheat; and, 5th, oats, peas, or sometimes, but rarely, beans. On the Chiltern lands the rotations are the same, with only slight variations. On both these last tracts of country, the cultivation of sainfoin is very extensive; occupying on most farms from one seventh to one eighth of the whole. This valuable artificial grass produces heavy crops. When it was first introduced, it would remain productive for fifteen or sixteen years; but since it has become more familiarized to the soil, it seldom lasts more than seven years so as to be fit to make hay, but yields food for sheep for one or two years afterwards. The sheep, which were formerly almost all of the Berkshire breed, have of late years been superseded by the race of the South Downs.

Oxfordshire is not a manufacturing district. Witney was long celebrated for its blankets, and still retains its fame; but, in spite of the machinery which has been introduced to diminish the price, the manufacturers of Yorkshire and Lancashire excel those produced here. At present, however, this trade gives employment to 270 persons in the town and two adjoining hamlets. At Banbury, and its adjacent hamlet Neithrop, 125 persons are occupied in making plushes and girth-webs, and a number in some other parishes within the county. Gloves of a superior kind are made at Woodstock and its vicinity; and

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there are some of the finer kinds of cutlery made in that town. Sacking is made at Abingdon and at Henley; and many axles and coach-wheels at Henley-on-Thames.

The rivers all discharge themselves into the Thames. They are formed by the numerous small springs which are everywhere to be seen; and before they join the Thames, are called the Windrush, coming from Burford and Witney; the Evenlode, from Wichwood and Charlbury; and the Cherwell, from the vicinity of Banbury. The Thames, composed of the stream of that name and the Isis (on which a strange confusion has arisen), is navigable from near one of its sources, not far from Leachlade, to the sea. The barges navigating it are from seventy-five to one hundred tons burden, but the larger ones ascend no higher than Oxford. From the frequent recurrence of shoals, owing to the floods in winter, and the scarcity of water in summer, it is a dilatory navigation; so that frequently the passage from America to London occupies less time than from Leachlade to that city. The scarcity of fuel was severely experienced till within these last few years; but the completion of a canal which connects the city of Oxford with the collieries of Staffordshire has removed the evil, and proved highly profitable to the proprietors of that important work.

The city of Oxford, the glory of this county and of the kingdom, has already been described.

The antiquities of this county have been accurately described, and are deserving of the closest inspection. Amongst them are traces of the various roads formed by the Romans, whose principal station was at Dorchester; besides many funereal mounds, and the Vallum, called the Devil's Ditch. The Priory of Godstow, and the ruins of many other religious houses, exhibit the architecture of different and remote ages.

The population of this county, according to the returns at the four decennial enumerations, has been as follows, viz. in 1801, 109,620; in 1811, 119,191; in 1821, 136,971; and in 1831, 152,100.

The occupiers of land employing labourers were	2054
Occupiers of land not employing labourers	458
Labourers employed in agriculture	15,998
Labourers employed in manufactures	711
Labourers employed in retail trade or handicraft	11,110
Capitalists, bankers, &c	2,254
Labourers not agricultural	3,049
Other males under twenty years of age	2,547
Male servants	1,223
Female servants	5,571

The towns within this county which contain more than 1000 inhabitants are the following:

Oxford	20,640	inhabitants.
Banbury	5,906	...
Witney	5,336	...
Henley-on-Thames	3,618	...
Bicester	2,868	...
Thame	2,885	...
Chipping Norton	2,637	...
Burford	1,866	...
Watlington	1,833	...
Bampton	1,605	...
Deddington	1,590	...
Woodstock	1,380	...

The whole county is in the diocese of its chief city. The members returned to the House of Commons under the new law are, three for the county, who are polled for at Oxford, Witney, Deddington, and Nettlebed; two each for the city and for the university of Oxford; and one each for the boroughs of Banbury and Woodstock.

The most distinguished residences are, Blenheim Castle, Duke of Marlborough; Blandford House, Duke of Beaufort; Brightwell, W. Lowndes Stowe, Esq.; Cuddesdon Palace, Bishop of Oxford; Crowsley Park, John Atkins Wright, Esq.; Ditchley Park, Lord Dillon; Grey's Court, Lady Stapleton; Heythorp, Earl of Shrewsbury; Kirtlington Park, Sir H. W. Dashwood; Middleton Stoney, Earl of Jersey; Mongewell, Bishop of Durham; Mapledurham, Michael Blount, Esq.; Nuneham Park, Lord Vernon; Rycot Park, Earl of Abingdon; Shiplake, Lord Mark Kerr; Shelswell, —— Harrison, Esq.; Shirburn Castle, Earl of Macclesfield; Thane Park, Miss Wykham; Wroxton, Earl of Guildford; Waterstock, W. H. Ashhurst, Esq.; Wormsley, John Fane, Esq.; Wheatfield, Lord Churchill.

(See the *Agricultural State of Oxfordshire*, by Arthur Young; Pott's *Oxfordshire;* and Brewer's Account of Oxfordshire, in the *Beauties of England and Wales.*)

Oxgang ‖ Oxus.

OXGANG, or OXGATE, is generally taken, in our old law-books, for fifteen acres, or as much ground as a single ox can plough in a year.

OXUS, or AMMU. This great river of Central Asia has its source in the high lands of Pamer, a branch of the main ridge of the Hindu Coosh Mountains, which, extending northward, forms the boundary between Thibet and Great Bukharia. It issues from a glacier in a narrow valley 200 or 300 yards broad, which is enclosed on three sides by the high snowy mountain called Pooshtikhur. The stream is seen flowing from under the ice, which is stated to be at least forty spears in depth. The spring itself is buried under the great mass of ice whence it issues, and cannot be seen; but there is no doubt of its issuing from this spot, as there is no other open or break from which it could issue at any more distant point. The small but swelling stream is carried north in this narrow valley for five coss or ten miles; at eight miles it is twenty yards broad, and breast deep; and on leaving the valley, after being joined by many other springs from the same hill, it is fifty yards broad, and about four feet deep. It is joined by the Shiber about sixty miles from its source, which is sixty yards broad. The Oxus, however, is much broader, having been joined by seven or eight streams from knee to middle deep, and from ten to thirty yards broad. It flows in a south-west direction for 120 miles, and then meets a high ridge of mountains running from west-north-west to east-south-east. From this point it takes a west-south-west course through the wild and mountainous regions which separate the country of Balkh from Independent Tartary, until it breaks through the ridge in its progress southward, and meets some of the ridges which diverge from the main ridge of Hindu Coosh. In this part of its upper course, being a distance of more than 300 miles, it is confined between the mountains, and is joined by numerous streams, from two to four of which are crossed in each day's journey along its left or southern bank, besides two very considerable rivers, namely, the Soorkhab or Kurategeen River, and the Kokcha or Budukshan River. It also receives the tribute of many streams from the north, the names of which are unknown in Europe. Its course is now west-north-west; and it passes the far-famed city of Samarcand, which, however, is not situated on its banks, but on a river flowing into it. To Bukharia, which is situated on one of its tributary streams, it has a northerly course of 250 miles, being forced off in this direction by the high land of Hindu Coosh, which extends north of the ridge a considerable distance, and runs over a flat country, sandy, and little better than a desert. From this point to Ourgunge is a distance of 400 miles, over a desert of at least 300 miles, with only a few habitations of horse-breeders along the banks. On the left bank is a forest the greater part of the way, through which those who pass are obliged to carry their provisions for eight or ten days at a time. Mr Elphinstone has thus traced

Oxycrate ‖ Oxygen.

its course for 900 miles; and other travellers in the East have gleaned scanty information respecting its lower course till it terminates in the Sea of Aral after a course of 1200 miles. Frazer mentions, on the authority of a native traveller or merchant, that after passing the town of Ourgunge, it makes a turn to the east, and is joined by the Seer or Sihon (the Jaxartes), when both spread out into a large lake, which has no outlet, its waters being absorbed by the sand of which the surrounding country is composed. Frazer seems to think that this account corresponds so well with that of the Arabian and the Persian geographers, that there is no denying credit to it. But the accounts of native travellers are proverbially so erroneous, that no reliance can be placed upon them. They generally travel for the purposes of trade, and pay little attention to the geography of the country, or other details; and this, joined to their known carelessness of truth, renders their testimony of little value. Colonel Kinneir mentions, that Sir John Malcolm conversed with a native, who assured him that the termination of the river was in the Caspian Sea. This opinion is, however, strongly combated by Mr Frazer, who affirms that there is nothing like evidence to prove that the Oxus ever reached the Caspian Sea; that this notion rests on vague tradition, founded on ignorance; and that all the native authorities who speak directly to this point constantly say that the Jeyhoon or Ammu falls into the lake of Khaurezm. The ancient geographers were ignorant that there were two distinct lakes in Asia, namely, the Caspian Sea, and that of Aral. They supposed that both formed one lake; and hence their error was extremely natural, in giving a termination to the Oxus in the Caspian, the only outlet which they knew to exist in the direction of its stream. But we know for certain that no river falls into the Caspian to the south of the bay of Mangulshuck; for the caravans that pass and repass from Astrabad to Khyvah, and from thence to Mangulshuck, do not cross a single stream, or meet with a drop of running fresh water, after crossing the river Attruck near Astrabad. It is equally certain, from the same evidence, that no branch of the Oxus falls into the Caspian to the northward of Mangulshuck. Mr Frazer, in answer to his inquiries concerning the rise of the Oxus or Ammu, was informed by a traveller who saw it in the summer season near Balkh, that it was as large as the Jumna in its fullest season, and perfectly navigable for boats, which are in common use for crossing the stream, and for the conveyance both of goods and passengers from Balkh and from Bukharia to Ourgunge and Khyvah. At Bukharia it is a very large river, the stream being at no time less than a thousand yards wide; and in summer, when the snow melts, it sometimes spreads to the breadth of four miles. It is deep, and navigable for boats, by which means an active intercourse is maintained in most parts of its course. (F.)

OXYCRATE, an old term in *Pharmacy*, denoting a mixture of vinegar and water, proper to assuage, cool, and refresh. The usual proportion is one spoonful of vinegar to five or six spoonfuls of water.

OXYDE, or OXIDE, in *Chemistry*, is the term employed to denote a very numerous class of bodies formed by the union of certain bases with a smaller proportion of oxygen than what is necessary for their conversion into acids. See CHEMISTRY.

OXYDATION, or OXIDATION, is a term employed to express the process by which bodies are converted into oxides. See CHEMISTRY.

OXYGEN, a term adopted in the chemical nomenclature to express the acidifying principle, and formed from ὀξυς, *acid*, and γινομαι, *to generate*. It is not found naturally in a separate state, but always in combination with some other substance. In its aëriform or elastic state it is called oxygenous gas, and is the same as the dephlogisticated air of Priestley and Cavendish, the empyreal air of Scheele, and the vital or pure air of other chemists. See CHEMISTRY.

Oyer ‖ Ozanam.

OYER, in law-books, seems to have been anciently used for what is now called *assizes*. See ASSIZE.

OYES, a corruption of the French OYEZ, *Hear ye;* a term or formula frequently used by the criers in our courts on making proclamations, or to enjoin silence.

OYOLA, one of the larger Navigators' Islands, in the South Pacific Ocean, separated from Maouna or Massacre Island by a strait nine miles wide. It is mountainous towards the centre, from which the land slopes with a gentle declivity to the sea. Long. 171. 25. W. Lat. 14. S.

OYSTER HARBOUR, a bay on the south-west coast of New Holland, and north part of King George the Third's Sound, discovered by Vancouver in 1791. Long. 118. 15. E. Lat. 34. 58. S.

OYSTER *Island*, an island situated in the Bay of Bengal, and extremely dangerous to vessels, as it rises very little above the level of the sea, and is surrounded by rocks. It abounds with small rock-oysters, which the natives of the opposite coast catch with hammers and carry to Chittagong, whence they are conveyed to Dacca and Calcutta. It is nine miles south-south-west of the north point of the Arracan River.

OZANAM, JAMES, a laborious mathematician, was born in the year 1640, at Bouligneux, in the principality of Dombes. His family was of Hebrew extraction, but had long been converts to the Catholic faith; and some of them had held considerable places in the parliament of Provence. Nature had given him a decided taste for the exact sciences; but his father, who intended him for the church, took care not to foster an inclination adverse to his views; and, during four years, young Ozanam studied divinity, though with little pleasure or success. As he advanced in years, his aversion to this study increased in the same proportion as his ardour for the sciences, to which he was denied access, became more and more intense. His father, however, died just as he was about to complete his course of theology; and being now his own master, he renounced all idea of entering the church, and, devoting himself entirely to the mathematics, made so great progress that, at the age of fifteen, he composed a work in which he afterwards found some things deserving of publication. As, by the custom of Bresse, the estate went to the eldest son, the subject of this notice had no other resource than to teach mathematics, which he had not been permitted to study; and, accordingly, having established himself at Lyons, he there supported himself for some time by the produce of his lessons, supplying the deficiency by his gains at play. Some foreigners, pupils of his, to whom he had lent fifty pistoles without taking any note or obligation for repayment, having mentioned the circumstance to the father of Chancellor d'Aguesseau, that magistrate, touched with so generous a trait of character, invited Ozanam to come to Paris, where he would necessarily find greater facilities for teaching than at Lyons. Ozanam accepted this proposition the more readily, because he desired above all things to make the acquaintance of the great geometers whose works he had studied; and having abandoned play in order to devote himself entirely to the mathematics, he had soon a great number of pupils. But at first he wanted the prudence necessary to profit by his success. He was young, handsome, and sprightly, and being addicted to gallantry, he became entangled in some intrigues which, besides the annoyance they gave him, exposed him to considerable ridicule. Reflection followed, and celibacy appearing to him a dangerous state, he married a young woman almost without fortune, who had interested him by an air of gentleness, modesty, and virtue. Nor, adds Fontenelle, did these fair appearances deceive him. Satisfied with his condition, he divided his time be-

Ozanam. tween study and teaching. He gave lessons during peace; and the time of war he employed in composing works which added to his ease and comfort as well as to his reputation. He had as many as twelve children, who nearly all died at an early age, and whom he regretted, says his panegyrist, "comme s'il eût été riche, ou plutôt comme ne l'étant point; car ce sont les plus riches qui se tiennent les plus incommodés d'une nombreuse famille." He lost his wife in 1701, and with her all the comfort and happiness of his life. Neither did this misfortune come single. The war of the succession, by depriving him of his scholars, reduced him to a melancholy condition. But his patience was never for an instant ruffled, and notwithstanding the difficulties in which he found himself involved, he lost nothing of his gaiety. About this time he was admitted into the Academy of Sciences as an *élève*, a title which it was intended to elevate in general estimation by bestowing it on a man of Ozanam's age and merit. He appears to have had a presentiment of approaching death, arising perhaps from some latent disorder within; and under this impression he refused to receive some foreign noblemen who wished to become his pupils, alleging that he should not live long enough to carry them through a regular course. At length, on the 3d of April 1717, immediately after dinner, which he had eaten with some relish, he felt himself unwell, and asked to be put to bed; but a few minutes afterwards he was struck with an apoplexy, which in less than two hours carried him off. Ozanam was a man of a mild and calm disposition, of a cheerful and pleasant temper, and endeared by a generosity almost unparalleled. After marriage his manners were irreproachable. He was sincerely pious, although in matters of religion he did not allow himself to know more than the people, and studiously avoided intermeddling in theological disputes. He used to say that it was the business of the doctors of the Sorbonne to dispute, of the pope to decide, and of a mathematician to go to paradise in a perpendicular line. He composed with extreme facility, and never made any erasure or correction on his manuscripts, his first copy being always the last.

Besides editions of the *Eléments d'Euclide* of Père de Challes, of the *Géométrie Pratique*, and the *Traité du Sphère* of Boulanger, and some *Mémoires* in the Collection of the Academy, the *Journal des Savants*, and other publications, Ozanam wrote, 1. Tables des Sinus, Tangentes, et Secantes, et des Logarithmes, Lyon, 1670, and Paris, 1685, in 8vo; 2. Traité de Gnomonique, Paris, 1673, in 12mo; 3. La Géométrie Pratique, ibid. 1684, in 12mo; 4. Traité des Lignes de premier genre, de la construction des Equations, etc. ibid. 1687, in 8vo; 5. L'Usage du Compas de Proportion expliqué, ibid. 1688, in 8vo; 6. Dictionnaire Mathématique, ibid. 1690, in 4to; 7. Cours de Mathématiques, ibid. 1693, in five vols. 8vo, reprinted at Amsterdam in 1799; 8. Traité de la Fortification, containing the ancient and modern method for the construction and defence of strong places; 9. Récréations Mathématiques et Physiques, ibid. 1694, in two vols. 8vo; 10. Nouvelle Trigonométrie, 1699, in 12mo; 11. Méthode facile pour arpenter ou mésurer toutes sortes de Superficies, ibid. 1699, in 12mo; 12. Nouveaux Eléments d'Algèbre, Amsterdam, 1702, in 8vo; 13. La Perspective Théorique et Pratique, ibid. 1711, in 8vo; 14. La Géographie et Cosmographie, qui traite de la Sphère, ibid. 1711, in 8vo. Ozanam left in manuscript a treatise on the Analysis of Diophantus, which was in the library of D'Aguesseau. (See his *Eloge* by Fontenelle, the *Mémoires* of Niceron, and the Dictionary of Chaufepie.) (A.)

Ozell ‖ Ozolæ.

OZELL, John, a well-known translator, who received the rudiments of his education in the free school at Ashby de la Zouch, and completed his grammatical studies at Christ's Hospital, where he acquired a considerable knowledge of Latin, Greek, and Hebrew. It was the intention of his friends to send him to Cambridge; but, averse to the confinement of a college life, and perhaps disinclined to the clerical profession, he solicited and obtained employment in a public office of accounts, a situation for which he had been at much pains to qualify himself. His attention to business, however, did not divert his thoughts from literature. He made himself master of the principal modern languages, especially French, Italian, and Spanish; and from all these, as well as from the Latin and the Greek, he favoured the world with translations, which, if not remarkable for elegance, are generally pretty faithful to the originals. Ozell, though evidently a prudent man, had nevertheless a more exalted notion of his own abilities than the world was disposed to entertain; and this vain conceit probably led Pope to give him a place in the Dunciad, a species of distinction which seems to have annoyed him excessively. He died in the year 1743. (A.)

OZIERI, a city of the island of Sardinia, the capital of the diocese of the same name. It stands on a beautiful slope, in a healthy district, in which excellent wheat is raised and large flocks of sheep are pastured. Besides the cathedral, it contains several nunneries and monasteries, an hospital, and 7200 inhabitants.

OZERNAIA, a fortress of Asiatic Russia, in the government of Orenburg, on the Oural, and so named from the lakes by which it is surrounded. The village contains a church and 200 houses.

OZOLÆ, or Ozoli, a people who inhabited the eastern part of Ætolia, called *Ozolea*. This tract of territory lay at the northern extremity of the bay of Corinth, and extended about twelve miles. The name *Ozolæ*, on account of its indelicate signification, was highly disagreeable to the inhabitants; and they therefore exchanged it for that of Ætolians.

P.

P A C — P A D

P ‖ Pacajes.

P, THE fifteenth letter and eleventh consonant of the alphabet. The sound of it is formed by expressing the breath somewhat more suddenly than in forming the sound of *b*; but in other respects these two sounds are pretty much alike, and hence are often confounded. When *p* stands before *t* or *s*, its sound is lost; as in the words *psalms*, *psychology*, *Ptolemaic*, *ptisan*, and the like; but when placed before *h*, then both together have the sound *f*, as in *philosophy*, *physic*, and many other words. *P* and *B* are so like each other, that Quintilian declares, that in the word *obtinuit*, his reason required him to put a *b*, but that his ears could hear nothing but a *p*, *optinuit*; and hence, in ancient inscriptions and old glossaries, it appears that these two letters have often been confounded. Several nations still pronounce one for the other; the Welch and Germans particularly, who say, *ponum vinum*, for *bonum vinum*. Plutarch observes, that it was usual for those of Delphi to say βατειν for πατειν, βιχρον for πιχρον; and amongst the Latins, as often as an *s* followed, the *b* was changed into a *p*, as *scribo*, *scripsi*.

As an abbreviation, P stands for *Publius*, *Pondo*, &c. PA. DIG. for *Patricia Dignitas*; P. C. for *Patres Conscripti*; P. F. for *Publii Filius*; P. P. for *Propositum*, or *Propositum publicum*; P. R. for *Populus Romanus*; P. R. S. for *Prætoris sententia*; P. R. S. P. for *Præses provinciæ*. P. M. amongst *Astronomers*, is frequently used for *post meridiem*, or afternoon; and sometimes for *post mane*, after the morning, that is, after midnight. P was also used amongst the ancients as a numeral letter, signifying the same with the G, viz. a hundred, according to the verse of Ugutio,

P similem cum G numerum monstratur habere;

though Baronius is rather inclined to think that it stood for seven. When a dash was placed on the top of $\overline{P}$, it stood for four hundred thousand.

St Jerome, treating of Daniel, observes, that the Hebrews had no *P*, but that the *ph* served them instead of it; adding, that there is but one word in the whole Bible read with a *P*, viz. *apadno*. The Greek π signifies 80. On the French coins, *P* denotes those that were struck at Dijon.

In the Italian music, P stands for *piano*, or softly; and P. P. P. for *pianissimo*, or very softly. Amongst physicians, P stands for *pugil*, or the eighth part of an handful; P. Æ. *partes æquales*, or equal parts of the ingredients; P. P. signifies *pulvis panium*, or Jesuits' bark in powder; and *ppt. preparatus* or prepared.

PABULUM, amongst natural philosophers, is the same with Fuel.

PACAJES, a province of Bolivia, in South America, in the department of La Paz. It lies in the vicinity of the great lake of Titicaca, but its dimensions cannot be exactly stated. Being in the neighbourhood of the Andes, its climate is cold, and its soil not very productive. The inhabitants, who are distributed in about fifteen small settlements, consist chiefly of Indians, and are employed for the most part in tending cattle and sheep, with which the province abounds, being well adapted for grazing. Several mines of silver and emeralds were formerly worked here, but this pursuit is now abandoned. There is a mine of talc, however, which supplies the whole of Bolivia and Peru with plates of that substance, which is used as a substitute for window-glass. Pacajes, the capital of the province, is situated eighty miles south-west of La Paz, in a variable climate. Its chief commerce consists in the sale of cattle to the neighbouring towns.

Paccalongan ‖ Padah.

PACCALONGAN, a small European town and fort on the northern coast of the island of Java. It is the seat of the resident, and is chiefly peopled by natives and Chinese, though there are a few Dutch families. It is situated on the great road across the island, and near a forest, which is remarkably unhealthy. It is 282 miles east from Batavia.

PACE, a measure taken from the space between the two feet of a man in walking, being usually reckoned two feet and a half, and in some men a yard or three feet. The geometrical pace is five feet; and 60,000 such paces make one degree on the equator.

Pace, in the manège, is of three kinds, viz, walk, trot, and gallop; to which may be added an amble, because some horses have it naturally. Horses which go shuffling, or with mixed paces between the walk and amble, are for the most part of no value. This commonly proceeds from their fiery temper, but sometimes from a weakness in their reins or legs.

PACEM, a town on the north coast of the island of Sumatra, the capital of a kingdom of the same name, dependent on Acheen. It contains above 500 families, and is 120 miles south-east of Acheen.

PACHAMAC, a valley of Peru, in South America, ten miles south of Lima. It is celebrated for its pleasantness and fertility, but still more on account of a magnificent temple built by the Incas of Peru, in honour of their gods. When the Spaniards conquered Peru they found immense riches in this temple.

PACIFIC Ocean, the vast ocean which separates Asia from America. It is called *Pacific*, from the moderate weather which the first mariners who sailed in it experienced between the tropics; and it was called *South Sea*, because the Spaniards crossed the isthmus of Darien from north to south when they first discovered it, though it is properly the Western Ocean with regard to America.

PACKANGA, a town on the eastern coast of the Malay peninsula, situated on the river of the same name. It has now lost much of its former importance, though it is still conveniently situated for trade. Lat. 3. 32. N.

PACKET, or Packet-Boat, a vessel appointed to carry by sea, in the most expeditious manner, the mail of letter-packets, and expresses, from one kingdom to another.

PACTOLUS, in *Ancient Geography*, a river of Lydia, rising in Mount Tmolus, and also called *Chrysorhoas*, from its rolling down golden sand. From this river Crœsus is thought to have derived all his riches.

PACUVIUS, Marcus, of Brundusium, in Calabria, a tragic poet of high reputation, who flourished about the year of Rome 600. He was nephew of Ennius; published several theatrical pieces, of which only some fragments remain; and died at Tarentum at above ninety years of age.

PADAH, a town of Hindustan, in the province of Gundwaneh, and district of Gangpoor, situated on the east side of the Soanke River, and belonging to an independent Hindu chief. Long. 84. 45. E. Lat. 22. N.

Padang ‖ Padua.

PADANG, a small island in the Eastern Seas, near the west coast of Borneo. Long. 109. 21. E. Lat. 0. 33. S.

PADANG-GUCHI, a small river of Sumatra, which runs into the sea on the western coast, between the 4th and 5th degrees of south latitude.

PADANG, one of the principal Dutch settlements on the west coast of Sumatra, and to which all the other factories, as Pulo Chinco, Priaman, and Adjerhadja, were formerly subordinate. The town, with the fort, which is a square with four bastions of stone, is situated one mile up the river. There are on the opposite side mountains which command the fort at the distance of about 300 yards. Some pepper, camphor, and benzoin, are furnished; but since the establishment of the English at Bencoolen the quantity collected has been small. Padang was first visited by the English East India ships in 1649; it was then in possession of the Dutch, who retained it till 1781, when it was taken by the British, but given up at the peace of 1783. These settlements were again taken in 1794, but were given up to the Dutch at the general peace of 1814.

PADDINGTON, one of those parishes in the county of Middlesex which, by the increase of building in the vicinity of the metropolis, may be considered as a part of London, with which it is in contact on the north-east part. This in some measure accounts for its rapid growth, which has also been accelerated by the Grand Junction Canal terminating in a capacious basin furnished with storehouses for goods of all kinds. The parish-church is in the centre of a small green, and is an elegant object; and some new churches are in progress. In 1801, the population amounted to 1881, in 1811 to 4609, in 1821 to 6476, and in 1831 to 14,540.

PADDOC, or PADDOC-COURSE, a piece of ground encompassed with pales or a wall, and taken out of a park, for exhibiting races with greyhounds, for plates, wagers, and the like.

PADERBORN, a city of the Prussian province of Westphalia, in the government of Minden, and the capital of a circle of the same name, which extends over 108 square miles, and comprehends two cities, two towns, and thirty-eight villages, with 26,500 inhabitants. The city is built on the river Pader, and contains one Lutheran and four Catholic churches, two ancient monasteries now secularised, and one nunnery. It has 900 houses built in a very antique style, and a population of 7639 persons, chiefly Catholics. It was celebrated for a peculiar kind of linen, to which it gave its name. There are now some extensive breweries and distilleries. Long. 8. 38. 21. E. Lat. 52. 45. 32. N.

PADIHAM, a township and chapelry in the parish of Whalley, in the hundred of Blackburn, of the county of Lancaster, 213 miles from London. In 1801 the population amounted to 2118, in 1811 to 2556, in 1821 to 3060, and in 1831 to 3529.

PADSTOW, a seaport and market-town of Cornwall, in the hundred of Pydar, 243 miles from London, and thirty from Launceston. It is situated on the left bank of the river Alan or Camel, where there is a harbour which is rather difficult to enter, but secure within, and containing water for vessels of five hundred tons burden. It has a considerable pilchard fishery; and in summer it is resorted to for sea-bathing. The market is held on Saturday. In 1801 the population amounted to 1332, in 1811 to 1498, in 1821 to 1700, and in 1831 to 1822.

PADUA, a delegation of the Austrian province of Milan, in Italy, bounded on the north by Treviso, on the east by Venice, on the south by Polesina, and on the west by Verona and Vicenza. It extends over 837 square miles, is divided into twelve districts, containing 104 communes, and has a population of 296,000 persons. The land, except on the west side, is an extended plain. It is drained by the rivers Etsch, the Brenta, and the Musone; and it has numerous canals, which serve, many for irrigation, and some for navigation. The agriculture is well conducted, and yields abundantly wheat, maize, rice, and all kinds of horticultural products. Fruit is in superfluity, and much wine is made. Olives, hemp, flax, and silk are copiously grown, and afford employment to manufacturers, who fabricate various kinds of goods.

Padua ‖ Pagan.

PADUA, a city, the capital of the delegation of the same name, in Italy. It is built on the river Baglioni, which is connected by a canal with the several lagunes. It is surrounded with walls and ditches, and defended by several bastions. It has several fine squares, but the streets are narrow, and in general filthy, though they contain some very magnificent buildings, especially the palace or state-house, the university, and the theatre. Besides the cathedral, it contains ninety-six churches and chapels, sixteen hospitals, and 6000 houses, with 46,300 inhabitants. Its university is an establishment of great celebrity, and has at present upwards of forty professors, though only about three hundred pupils. There are depending on it an observatory, an anatomical theatre, a library with 60,000 volumes, and similar institutions. It is a place of some trade in the manufacturing of woollen goods, which, however, are chiefly of the coarser kinds. There are also silk and linen manufactures, a trade in wine, oil, and leather, and a transit commerce by the canal. Long. 11. 46. 38. E. Lat. 45. 23. 40. N.

PADUAN, amongst medallists, a modern medal struck in imitation of the antique, or a new medal struck with all the marks and characters of antiquity. This name is properly applicable to those medals only which were struck in the seventh century by an Italian painter born at Padua, who succeeded so well in the imposture, that the best judges are at a loss to distinguish his medals from the genuine ones; but it is also used to signify all medals of this kind.

PADULA, a town of Naples, in the province of Principato Citeriore. It stands in the Valley of Diana, between hills, and contains 5900 inhabitants.

PADUS, now the Po, anciently called *Eridanus*, especially by the Greeks, a river of Italy, celebrated in fable.

PÆAN, amongst the ancient pagans, was a song of rejoicing sung in honour of Apollo, and chiefly used on occasions of victory and triumph.

PÆAN, in the ancient poetry, is a foot consisting of four syllables, of which there are four kinds; the pæan primus, secundus, tertius, and quartus. The pæan primus consists of one long syllable and three short ones, or a trochæus and pyrrhichius, as *temporibus;* the pæan secundus consists of a short syllable, a long, and two short, or an iambus and a pyrrhichius, as *potentia;* the pæan tertius consists of two short syllables, with a long and a short one, or a pyrrhichius and a trochæus, as *animatus;* and the pæan quartus consists of three short syllables and a long one, or a pyrrhichius and iambus, as *celeritas.*

PÆDO-BAPTISM, infant baptism, or that conferred on children: from *παις, infant,* and *βαπτισμα, baptism.* This has been the subject of great controversy in the church.

PAGAHM, an eminent city of the Burman empire, situated on the eastern bank of the Irrawuddy. This city was formerly the residence of a dynasty of kings, and it still contains numerous temples, in a superior style of architecture to those built in later times. Little remains of the city except a brick rampart. It has, however, a good market, well supplied with grain, oil, fish, and vegetables. Long. 94. 35. E. Lat. 21. 9. N.

PAGAN, BLAISE FRANCOIS COMTE DE, an eminent French mathematician, was born at Avignon, in Provence, on the 3d of March 1604, and embraced the profession of arms at fourteen, having been bred to it with the great-

Paganalia || Pagninus.

est care. In 1620 he was engaged at the siege of Caen, in the battle of Pont de Cé, and the reduction of the Navarrese, and the rest of Béarn, where he signalized himself, and acquired a reputation far surpassing his years. He was present in 1621 at the siege of St John d'Angeli; as also at that of Clarac and Montauban, where he lost his left eye by a musket-shot. After this time there happened neither siege nor battle in which he did not signalize himself by some effort of courage and conduct. At the passage of the Alps and the barricade of Suza, he put himself at the head of the forlorn hope, and immediately began a furious assault, and, the army coming to his assistance, forced the barricades. When the king laid siege to Nancy in 1633, Count Pagan had the honour to attend his sovereign, in drawing the lines and forts of circumvallation. In 1642 his majesty sent him to serve in Portugal in the capacity of field-marshal; and in the same year he unfortunately lost his eye-sight. But though he was thus disabled from serving his country in the field, he resumed, with greater vigour than ever, the study of the mathematics and fortification, and, in 1645, gave the public a treatise on this latter subject. In 1651 he published his Geometrical Theorems, which show a perfect knowledge of all parts of the mathematics. In 1657 he published his Theory of the Planets, a work which distinguished him amongst astronomers as much as that on fortification did amongst engineers; and, in 1658, his Astronomical Tables. Count Pagan died at Paris on the 18th of November 1665.

PAGANALIA, certain festivals observed by the ancient Romans in the month of January. They were instituted by Servius Tullius, who appointed a certain number of villages (*pagi*), in each of which an altar was to be raised for annual sacrifices to their tutelar gods; at these all the inhabitants were to assist, and give presents in money, according to their sex and age, by which means the number of country people was known. The servants upon this occasion offered cakes to Ceres and Tellus, in order to obtain plentiful harvests.

PAGANISM, the worship or adoration of false gods.

PAGEANT, a triumphal car, chariot, arch, or other similar decoration, variously adorned with colours, flags, &c. carried about in public shows and processions.

PAGES, three small rocky islets in the strait between Kangaroo Island and the main shore of New Holland. Long. 138. 21. E. Lat. 35. 46. S.

PAGI, Antony, one of the ablest critics of his time, was born at Rogne in Provence in the year 1624. He devoted himself to the study of chronology and ecclesiastical history, in which he excelled. His principal work is, a criticism on the Annals of Baronius, in which he has rectified a great number of mistakes both in chronology and in facts. Pagi died in 1699.

PAGNANI, a large market-town of Italy, in the province Principato Citeriore, of the kingdom of Naples. It now contains, with adjoining villages, 9630 inhabitants.

PAGNINUS, Sanctes, an Italian Dominican, eminent for his skill in oriental languages and biblical learning, was born at Lucca in 1466. He was deeply and accurately skilled in Latin, Greek, Hebrew, Chaldaic, and Arabic, but particularly in the Hebrew. He applied himself to examine the vulgar translation of the Scriptures; and believing it to be greatly corrupted, he undertook to make a new one from the Hebrew text. The design of Pagninus seemed a bold one; yet such was his reputation, that it was approved by Leo X., who promised to furnish him with all necessary means for carrying on the work, which was printed at Lyons in 1527. This is the first modern translation of the Bible from the Hebrew text. Pagninus, however, is thought to have adhered with too great servility to the original text, and thus to have rendered his translation obscure, barbarous, and full of solecisms. He also translated the New Testament from the Greek; and was author of a Hebrew Lexicon and a Hebrew Grammar. He died in 1536, aged seventy. Luther spoke of him and his translations in terms of the highest praise.

Pago || Painswick.

PAGO, an island in the Adriatic, forming a portion of the Austrian province of Dalmatia. It is long, and of a singular form, with several peninsulas, and abounds in salt lagunes, from which much culinary salt is made. The island abounds in excellent coal. It contains 4300 inhabitants of the Sclavonian race.

PAGOD, or Pagoda, a name given by the Hindus and others to the temples where they worship their gods.

Pagod, or *Pagoda*, is also the name of a gold and silver coin, current in several parts of the East Indies.

PAHANG, or Pulo Pahang, a small island in the Eastern Seas, near the coast of Malacca, five miles east from the town of Pahang.

Pahang, a town of Malacca, on the east coast, situated twelve miles from the sea, on a broad and shallow river, full of shoals. It is divided at its mouth, which is situated in lat. 3. 45. N., into two channels, which are navigable for small vessels up to the town. It is enclosed by a wall made of the trunks of trees joined close together, and about twenty-four feet in height. The streets are fenced on both sides with hedges of reeds, and planted with cocoa and other trees; so that it has more the appearance of an assemblage of gardens than of a regular city. It formerly carried on a considerable trade, and was visited by vessels from various parts of India, such as Bantam, Batavia, Japan, and China. At present the trade is carried on in vessels belonging to the place, in which are imported articles of European manufacture, such as iron, cutlery, glass; also piece-goods, woollens, tobacco, &c. In return they receive from the eastern islands cloves, elephants' teeth, mace, nutmegs, rattans, sago, tortoise-shell. Gold-dust, with which the river abounds, is also a principal article of trade. The mouth of the river is in lat. 3. 45. N.

PAHO, a river on the west coast of the isle of Celebes, which runs into the Straits of Macassar. Long. 119. 52. E. Lat. 3. 10. S.

PAIMBŒUF, an arrondissement of the department of the Lower Loire, in France, 287 square miles in extent. It comprehends five cantons, divided into twenty-five communes, and contains 42,580 inhabitants. The capital is the city of the same name, situated on the left bank of the Loire, and nine miles from its mouth. It has a good haven, where the larger ships discharge their lading into craft to convey it to Nantes. There are several establishments for building and repairing ships. In 1836 the city contained 800 houses and 3872 inhabitants.

PAINOMJEUNG, a castle of Thibet, situated on a perpendicular rock washed by a river which flows at its foot. Long. 89. 10. E. Lat. 29. N.

PAINSWICK, a market-town of the county of Gloucester, in the hundred of Bisley, 101 miles from London, and seven from Gloucester. It is pleasantly situated on the banks of a small stream which empties itself into the Stroud. The town is not large; but the parish is divided into four lythings, and contains 6510 acres of land. It is a place of great antiquity, having a church of various styles of architecture, with a tower, on which is a spire rising to the height of 174 feet. On the summit of a hill called Spire Head, adjoining to the town, are the ruins of an ancient fortification called Kingsbury Castle. It has a good market, which is held on Tuesday. The principal occupation consists in making superfine woollen cloths; and, by the population returns of 1831, the number of the families employed in trade and manufactures was 448, whilst those employed in agriculture were 195, and all others 243. In 1801 the population amounted to 3150, in 1811 to 3201, in 1821 to 4044, and in 1831 to 4099.

PAINTING.

Painting. Definition. PAINTING is the art of conveying thought by the imitation of things through the medium of form and colour, light and shadow. Colour, and light and shadow, can by themselves do little more than excite sensations of harmony and sentiment, independently of action, passion, or story; but if founded upon form, thoughts become clear, expressions of passion intelligible, and actions, gestures, and motions of the human frame defined and decided. *Form* therefore is the basis of painting, sculpture, architecture, and design of every description.

Any school of painting, therefore, which is established upon a principle different from this, or which makes the subordinate parts of colour, light, and shadow the principal law of its practice instead of a component part, is in opposition to the most celebrated schools in the world; for the most eminent both in Greece and in Italy, were indebted for their celebrity and renown to the strict observance of the doctrine here enunciated. In Greece, the schools of Sicyon, Corinth, Athens and Rhodes, and in Italy, those of Pisa, Florence, Rome, and Bologna, were the most important, the most useful, and the most intellectual; and in all these *form* constituted the great and fundamental law of their practice. But in Venice, colour took the lead; it predominated too in Holland and Flanders; and it has always reigned, to the sacrifice of common sense, in Britain. Yet for sound and philosophical views of art, as a vehicle of passion or of moral national influence, neither of these schools can be referred to, with the same conviction or confidence with which all nations can refer to the former great sources of sense, principle, and genius.

Origin of painting. In what country Painting first originated, is nearly as difficult to discover, as it is to find a country where it never existed at all. Design, the basis of painting, must have begun with the very first instrument of necessity which man required. The origin of any art, science, or discovery, is not so much owing to the particular accident which happened to the individual concerned, as to the intellectual adaptation of that individual to receive impressions of a peculiar nature from the particular circumstance which occurred. Thus whether Music was invented by the man, who, listening to the sound of an anvil, instantly composed notes; or whether Painting was discovered by the lovely girl, who, watching the shadow of her lover, as he sat silent at the prospect of parting, traced it upon the wall as a memento of their mutual affection; whether it originated with Philocles in Egypt, or Cleanthes in Corinth, or long before Egypt or Greece were habitable; the *principle* is the same. Without an inherent susceptibility to the impressions of sound, in preference to all other impressions, in the man, or an inherent susceptibility to the impressions of form equally intense in the girl, the intellectual faculties of either would have never been excited to compose notes, or to define figures. The art originated with the first man who was born with such acute sensibility to the beauty of form, colour, and light and shadow, as to be impelled to convey his thoughts by positive imitation.

When the Spaniards landed in South America, the mode by which the natives conveyed intelligence of their arrival to king Montezuma was by painting the clothes of the strangers, their looks, their dress, and their ships. This certainly must have been the most ancient, because the most simple and obvious mode in the world of conveying thought, after oral communication. But independently of all theory, there cannot be a doubt of the extreme antiquity of painting. The walls of Babylon were painted after nature with different species of animals, hunting expeditions, and combats. Simiramis was represented on horseback striking a leopard with a dart, and her husband Ninus wounding a lion. "And I went in and saw, and behold every form of creeping things, and abominable beasts, and all the idols of the house of Israel, *pourtrayed on the wall round about.*" (Ezek. viii. 18.) "She saw men *pourtrayed upon the wall*, the images of the Chaldeans *pourtrayed in vermilion*, girded with girdles upon their loins, exceeding in *dyed attire* upon their heads, all of them princes to look at, after the manner of the *Babylonians and Chaldeans.*" (chap. xxiii. 14, 15.) It is inferred from a passage of Diodorus Siculus, that these figures were painted first on the brick before burning, and then vitrified by fire.[1] But before this was done, experience must have been acquired of the liability to decay of painting upon external walls; and considering, too, that great statues were erected in Babylon, the arts must have existed amongst the Babylonians long before the period here referred to.

Painting.

Antiquity of art in Ethiopia. But a great revolution has taken place in our ideas on this subject, from the decyphering of hieroglyphics, and we are now assured of the extreme antiquity of art, in ages hitherto deemed almost entirely fabulous. From Asiatic art we have been accustomed to turn to that of the Egyptians; but it is no longer considered as a matter of speculation that the Ethiopians preceded the latter in knowledge, and that from this ancient people the Egyptians received gradually a knowledge of art. The course of civilisation probably descended from Ethiopia to Egypt; and yet we have evidence of the existence of Egyptian painting and sculpture more than eighteen centuries before Christ, and even then the arts were in the highest condition that the Egyptian school ever attained. From the most ancient records of the Jewish and Greek historians, in which Egyptian and Ethiopian monarchs are mentioned, and their actions narrated, we can now turn to corresponding traces of their existence and exploits commemorated upon the durable materials of the temples, tombs, and palaces which still remain. When therefore it is found that this method of interpreting hieroglyphics has proved to be correct, in all that we know of the Cæsars and the Ptolemies, or see casually alluded to respecting the Pharaohs, we have no right at all to dispute the truth of the same mode of interpretation when it indicates a still higher antiquity, though we have not the means of confirming it by collateral reference. Eighty miles above Dongola, Lord Prudhoe discovered the remains of a magnificent city, which he conceives to have been the capital of Tirhakah mentioned in the Bible; and amongst these ruins he observed two nobly executed lions, specimens of Ethiopian skill. On the shoulders of one is the name of Amenoph III., who was called Memnon by Greek historians. The style and execution of these great works are evidence of the talent of this people.[2] It is now certain that as early as the nineteenth century before Christ, the walls and temples of Thebes were decorated with paintings and sculpture, commemorating personal and historical events; and certainly in comparing the designs on these temples with those of a later period, we must conclude that the Egyptian school of painting never exceeded their merit.[3]

The conclusion to be drawn is, that at this time the Egyp-

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[1] Barry's *Lectures.* [2] Now in the British Museum. [3] See last vol. of Sculpture, *(Dilletanti.)*

Painting. tian priesthood had not interfered with art or artists; but that the painters were left freely to commemorate the great actions of their employers, to study nature, and to do as they liked. Many of these actions are delineated in a natural manner, and there is a great deal of dignity in the figure of the hero; the sea fights are also well grouped, and there are many of the Trajan-column figures, and not more gross perspective is visible. The colour is a mere illumination, and the composition as a whole infantine; but there is proportion, and not absolute ignorance of the component parts.[1] After this period, art became a mere tool in the hands of the priests; and as the law compelled the son to follow the profession of his father, it may be supposed that painting degenerated into the mere fac-simile of prescribed forms of gods, godesses, and men, and that in the time of the Ptolemies it was little better than an illuminated hieroglyphic.

Character of Egyptian design. The Egyptians appear to have done every thing with reference to form. Their painting was at best but coloured sculpture. They seem to have been aware of the mortality of colours, and to have said, "As colours must go, let us cut out the designs in stone, so that at least form may remain in our granite sculpture, and defy every thing but the convulsion of the earth." First the designer drew the outline in red, then the master artist corrected it, then the sculptor cut it, then the painter coloured it, gods blue, goddesses yellow, men red, and draperies green and black; and such is the extreme dryness of the climate, that a traveller says, he saw in Nubia, a bas-relief half cut, with the red outline left for the rest, and that he wetted his finger and put it up, and immediately obliterated a part of the red chalk.

The Egyptians would seem to have been a severe people, as hard as their own granite.[2] They had an awful feeling of respect for the wisdom of their ancestors; they hated reform; no physician dared to prescribe a new medicine, and no painter dared to invent a new thought. Plato says, that the pictures of his day in Egypt were just the same as from ages immemorial;[3] and, according to Winkelman, another cause of their inferiority in painting, was the little estimation in which painters were held, and their extreme ignorance. Not a single painter of eminence has reached us, and but one sculptor, viz. Memnon, author of three statues at the entrance of the great temple at Thebes. In the knowledge of the figure it is impossible they could be great; for there is proof that they dared not touch the dead body for dissection, and even the embalmers risked their lives from the hatred of the populace.

Winkelman divides Egyptian design into three periods: First, from the earliest times to the conquest of Cambyses; secondly, from the conquest of Cambyses to the subjugation of the Persian and the establishment of the Greek dynasty in Egypt; and, thirdly, from that period to the time of Hadrian.[4] When the paintings at Thebes were executed is not known. But they were upon the walls at the expulsion of the Shepherd Kings,[5] and this was the first period of their art, and before Moses. The Egyptians never, in either art, reached the power of making men, as Aristotle said of Polygnotus, *better* than they were; in other words, they never attained the true ideal beauty, founded on nature, yet above it. Their figures are debased transcripts of what they had about them, and therefore, so far authentic as to character. The Egyptian female heads are far from displeasing; they have a sleepy voluptuous eye,[6] a full and pleasant mouth, high cheek bones, dark brows, and there is something by no means disagreeable in the silent lazy look of their expression. But the very want of ideal beauty gives an assurance that the figures are Egyptian nature, and that every habit, public, private, civil and religious, is laid open to us, by the wonderful discoveries of Belzoni and his followers: it is almost as impossible now for an artist to be incorrect in painting an Egyptian subject, as it would be to err in painting a British one. In a tomb laid open by Belzoni, the characters of the procession were admirably distinguished; the Jew, the Egyptian, the Negro, and the Chaldæan, were as little liable to be confounded as if they had been before us. In their sculpture, however, there is more of science than in their painting. Sculpture was practised by the priesthood, and sculptors were called sacred stone-cutters. The great head of Memnon in the British Museum, is beautifully cut, the nose and mouth especially; and, considering its remote antiquity, it is really a great wonder. Painting.

Upon the whole, it is impossible to believe that the art of painting, amongst other nations, owed much to the Egyptians; they had no colour, and no light and shadow, but only some form, some expression, and some character. The groups of the ruins of Elythia shew a great deal of nature and simplicity; the animals are varied, and the cows are lowing and gamboling; yet it is after all but childish work, and as the paintings at Thebes are the best, those of Elythia have not much to boast of.

Whether the Greeks owe their beginnings to Egypt, is more than doubtful, from the simple fact of the early Greek painters using *no blue*, whilst it was the constant practice of Egyptian painters to use blue in every thing.[7] Athens was founded by an Egyptian colony, and painters might be amongst the emigrants, as well as masons and sculptors; yet in the early state of things, painters were not an article of necessity, and it is problematical if in this alleged emigration, there were any persons of that class. The beginning of art was the same in all nations. They might improve each other; but we do not believe that painting was ever originally brought into one nation by another, or that there ever existed any, where it has not always been more or less known from the remotest period of their history.

State of art amongst the Hebrews and other Eastern nations. After Ethiopian, and Egyptian art, that of the Hebrew people must next be examined. That they had sculptors and chasers, is evident; but it is not so certain that painting was practised. Though the cunning work of the curtains in Exodus means tapestry, and for any cunning work of the kind, designs coloured must have been executed; yet there is no proof in any part of the Bible that painting as an art was ever practised by them; and even the designs alluded to, were exclusively applied for the purposes of religion. "Moreover, thou shalt make the tabernacle with ten curtains of fine twined linen, with blue, and purple, and scarlet; with cherubim of cunning work shalt thou make them." (Exodus xxvi. 1.) "And the Lord spake unto Moses, saying, See, I have called by name Bezaleel the son of Uri, the son of Hur, of the tribe of Judah; and I have filled him with the spirit of God, in wisdom, and in understanding, and in knowledge, and in all manner of workmanship, to devise cunning works, to work in gold, and in silver, and in brass, and in cutting of stones, to set them, and in carving of timber, to work in all *manner of workmanship*." (Exod. xxxi. 1—5.) Yet when Solomon wanted artists, he sent to Tyre, which is presumptive evidence of a deficiency of skill at Jerusalem. No allusion is made to the existence of the art of painting amongst the Hebrews; yet it is hardly possible to suppose a people working in stone, and silver, and gold, and timber, designing and weaving a cunning work of cherubims on curtains and bor-

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[1] See the French national work on Egypt.
[2] *Odyss.* lib. xvii. v. 448.
[3] *De Legibus*, lib. 2.
[4] Wink. lib. ii. chap. 2.
[5] See 2d vol. of *Ancient Sculpture*, (Dilletanti.)
[6] See *Description de l'Egypte*, tom. i. plates.
[7] Col. Leake says there is a remnant of blue on the temple of Theseus; but that may be as applied to architecture. The question is, whether the great painters used it in their art. Pliny says no, and Quintilian confirms him by applying to them the expression *simplex color*. No colour is *simplex* where pure blue is used.

Painting. ders for garments, and having been so long amongst the Egyptians, to have been ignorant of painting; but it is the opinion of one of the greatest living authorities in the church, that the representation of any object by painting was not permitted to the Hebrews.

With respect to the painting of the Phœnicians, Persians, Indians, and Chinese, it was in the earliest ages, and has ever since been, miserable and wretched. Although the Indians and Persians have always been celebrated for their tapestry, yet it is more for the excellence of the material than the purity of their designs. You may know a tiger from an elephant, though scarcely from a monkey, in their tapestry, shawls, and carpets; but in their utter ignorance of the naked figure, their long, barbarous, and cumbersome garments, and their want of science, are so grossly palpable, that they have never been, and never will be, referred to by any nation as authority in design. In their coins, however, the ancient Phœnicians shewed more knowledge of the form than the Persians, the Chinese, or the Indians.

Etruscan art. From the painting of these Eastern nations, we may now justifiably approach a people, whose origin, history, and science, have puzzled historians more than perhaps the Atlantides themselves. Who the Etruscans were nobody knows; but all agree that they were not aborigines, and this is establishing something. Yet it can scarcely be questioned that in their most remote, as well as their more refined periods, they were indebted for their arts, their language, and their religion, principally to the Grecians. The time when the Etruscans had commercial relations with Egypt and Greece, is hardly known;[1] but as their early style of art is a little Egyptian and their subjects Grecian, they were no doubt connected with both, even before the Greeks had settled in Italy. It is not yet decided where they came from, and who they were, and if one consults all who have written on the subject from Herodotus to M. Raoul-Rochette, he is likely to be as open to a new theory as when he began. Their early works prove nothing. These are like the early works of almost all barbarous nations. The gods of the Etruscans are, in point of art, the gods of the Peruvians, the Sandwich Islanders, or the Esquimaux. Idols are idols, in early nations all over the world; and the bandy-legged Apollos, squinting Pans, and *Dii indigenetes*, sixteen heads high, of this mysterious people, would do as well for any of the gods of the South Seas, as the early barbarians of the Mediterranean.[2] When commerce brought them in contact with Greece and Egypt, traces of the art of both nations become apparent; but this is no evidence that they came exclusively from one nation or from the other.

Winkelman is a person of great genius, and always touches art as if he saw the whole ground. He divides Etruscan art into three epochs, Heyne into five;[3] he goes to leading points, Heyne enters into details. The first epoch was gross; the second exhibited traces of Greek or Pelasgic art; the third had a taint of Ægyptian; the fourth was better; the fifth produced ideal beauty and Greek mythology; and this completes the period till decay. Campania was colonized 801 B.C.; but the Eubæans had founded Cuma 1550 B.C. This neighbourhood brought the Etruscans in contact with Greek art, when about the ninth or eleventh Olympiad Greek colonies were established in Sicily; and the intercourse being reciprocal and complete, it cannot be wondered, that the more ignorant of the two nations became fascinated and inoculated by the superior one, and thus rendered Etruscan so like Greek art, that it has ever since produced doubt and confusion.

According to Pliny, the arrival of Demaratus with Cleanthes from Corinth, first brought art into Etruria about 650 B.C.; yet, he says, there were beautiful pictures at Ardea and Lanuvium, which were older than Rome, and Rome was founded 754 B.C. Heyne says, that before Rome was built, casting of metal, sculpture, and painting existed in Etruria anterior to any connection of the Etruscans with Greece; according to Winkelman the Etruscans were advanced in art before the Greeks, and it was a tradition of the remote ages, that Dædalus flying from Minos settled in Etruria and first sowed the seeds of design. When Etruria became a Roman province, Marcus Flavius Flaccus besieged Volsinium, the etymological meaning of which is, "The town of artists," and brought away two thousand statues from that city alone. An able writer, in the "Newcastle Transactions" contends, that it is doubtful if the Etruscans had any art before the arrival of the Greeks.[4] No historian of this nation has reached us; their inscriptions are not yet thoroughly decyphered; and as the Romans destroyed every monument of surrounding nations, there is no fixing their antiquity. It is clear, however, that painting flourished in Italy before it did in Greece; such at least is the opinion of Tiraboschi.[5] Pliny says nothing about it before the 18th Olympiad in Greece, whereas in the 16th there were paintings in the above towns in Italy, and works too shewing great refinement; which the Romans admired in their days of splendour, and which their emperors wished to remove, surrounded as they were by the finest productions of Grecian art. Their civil and religious rites not being the same as the Egyptians, and there being no traces of embalming, it may thence be concluded that they were not of Egyptian origin. Painting.

All hopes of discovering any of their paintings, any important work which should give us evidence of their talents in art, were given up, till in 1760 Pacciaudi discovered at Tarquinia, tombs decorated with designs; and in 1837 fac-similes of pictural decorations of other tombs were exhibited in London, with the monumental statues themselves, and in parts were extremely beautiful in taste, design, expression, and drapery. The extremities were correctly and sweetly drawn; and the expression and character of the head, which were very interesting, would not have disgraced any period of Greek or Italian design, though they would not have honoured the finest. It is impossible to judge of the colour of the Etruscan school from these specimens, or from the vases called Etruscan. Fresco, stucco, or distemper are adapted neither for depth nor for tone; oil or encaustic is the only vehicle fit for harmony, and oil or encaustic was never practised by them. With respect to the painted vases called Etruscan, because they are found in Etruria, we might just as well assert, if one discovered in the middle of Yorkshire, a mass of china, that it must be of English manufacture because it was found in Yorkshire. After the Greeks had settled in the south, their vases might be and no doubt were an article of commerce; of course they were imitated, but surely the design and origin are wholly Grecian, whatever the Etruscans might after long intercourse do in the way of imitation. The principles of design and proportion in these beautiful productions, are the same as in the finest works of Greek sculpture, with an occasional but trifling variation. Raffaelle himself could not have exceeded the purity of form expressed by line, in drapery or figure. In the finest vases the artists seem to have been perfect masters of the figure, and to have gone right round with the stylus, till the contour of the part was completely expressed. Nor is there any thing wonderful in this, considering the manner in which Greek artists and manufacturers began, proceeded, and concluded their studies. According to Plato, a perfect mastery of the forms

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[1] B.C. 1556. [2] See Gorius. [3] See Heyne's Notes on Winkelman, vol. i.
[4] This is a most able article, and the reader is referred to it for more extensive information on the Etruscans.
[5] *Storia della Letteratura Italiana.*

Painting. of man and animal was the basis of all instruction in design.

We have thus brought down the history of the art to a period, when our information, though imperfect, is more certain; but we can never sufficiently estimate the loss of all the ancient treatises on art, though we ought to be very grateful for what we possess in Plato and Aristotle, Pliny and Quintilian, and other ancient writers, Greek and Roman, down to the middle ages, and till the subject was taken up by Vasari and Lanzi. The continued existence of this glorious art, can always be proved, more or less subject of course, like every thing human, to those alternations of splendour and calamity, triumph and misfortune, which are the lot of every thing here below.

Greek school of art.

The superiority of the Greeks in art is always attributed to the secondary causes of climate and government, forgetting the one important requisite, without which the influence of the most genial climate, or the patronage of the most perfect government could avail little; we mean natural and inherent genius. If the Athenians, the Rhodians, the Corinthians, and the Sicyonians owed their excellence in art to the climate, why did not the same climate produce equal perfection in the Spartans and Arcadians? If climate be the secret, why are not all people under the same latitude equally gifted and equally refined? Climate may be more or less favourable to intellectual development, but is never the cause of its existence. Government may elicit genius by fostering and reward, but can never create it. All the lamentation about the climate of England, Scotland, or Flanders, did not prevent Hogarth's appearance in the first, Wilkie's in the second, or Rubens' in the last of these countries; nor could all the beauty of climate in Greece or Italy, ever have made Mengs a Raffaelle, or David the Titian of modern times. It would be absurd to deny altogether the influence of climate in the extremes. It is not impossible but that genius might melt to indolence under the line, or freeze to apathy within the arctic circle; but even genius there would assert its superiority in something or in some way. What we contend for is, that Winkelman's theory of limiting the gifts of God, intellectual or corporeal, to latitude or longitude, is not borne out by facts, the great test of all theoretical principles.

The Greeks were idolaters, and their love of beauty was a principle of their religion. The more beautiful a face or form could be rendered in painting or sculpture, the better chance had the artist of the blessing of the gods here, and their immortal rewards hereafter. As beauty was so much prized by this highly-endowed people, those who were gifted with it became ambitious of making it known to great artists, and by them to the world. Artists fixed the fame of beauty in man or woman, and even children who gave promise of being beautiful were allowed to contest for a prize, and the child who won it had a statue erected to him. Many people were complimented by being named from the beauty of any particular part, and Winkelman quotes an instance, where one was called Χαριτοβλεφαρος that is, "having eyelids where the graces sat." There were games instituted near the river Alphæus, where prizes were adjudged to the most beautiful; and the Lacedæmonian women in their bed-rooms kept continually before their eyes the finest statues. Still, this admiration of beauty was but a secondary cause; for though the Lacedæmonians showed this love of beauty, they did not produce great artists. The Greeks had a strong sensibility to beauty and an intense acuteness of understanding. Every artist was a philosopher, and every philosopher relished art, and understood it. The artists began by the study of geometry and of form; they analyzed the peculiarities of the form of man, by contrasting it with that of the brutes, and they settled the principles of beauty in that form and figure. The philosophers recommended to all classes the study of art, as a refined mode of elevating their perception of beauty; and the government seconded the recommendation of the philosophers. The priests found the religious feeling rendered more acute by painting and sculpture; and the authorities discovered, that the emotions of patriotism were doubled by the commemoration of great national events, in temples and in public halls. Now, add climate as adapted for such productions and their preservation, and genius, the gift of God, as the first cause, and no one surely need wonder that all these causes mutually acting on each other produced the miracles of perfection in art, which the world has gazed at ever since with an incredulous and bewildered astonishment. Painting.

The passion for the beautiful in poetry, painting, music, and nature, led them to abhor the bloody amusements of the Romans. To contest for glory by pictures, poems, or music, to race for the prize of swiftness, or wrestle for the crown of strength, were the innocent and delightful objects of their Olympic games; and during those noble commemorations, war ceased, and all Greece assembled in happiness and joy. Even the harsh Spartans signed a truce of fifty days with the Messenians, that they might keep a fête in honour of Hyacinthus. The greatest men disdained not these contests. Plato appeared amongst the wrestlers at Corinth, and Pythagoras carried off the prize at Elis. What must have been the effect of all this upon a people of strong susceptibilities and of high natural genius?

Consider the respect which must have been paid to great artists, when such a man as Socrates pronounced them the only wise men. Æsop took the greatest pleasure in lounging in their painting-rooms; Marcus Aurelius took lessons in philosophy from an artist, and always said that the latter first taught him to distinguish the true from the false; and when Paulus Æmilius sent to the Athenians for one of their ablest philosophers to educate his children, they selected Metrodorus the painter, and, let it be remembered, that amongst the children placed under *his* care, was one of the Scipios. What must have been the effect on the rising youth of Greece when the Amphictyonic council decreed that Polygnotus, their greatest monumental painter, should be maintained at the public expense wherever he went, as a mark of the national admiration for his greatest work, the Hall at Delphi. The glory and the fortune of a great painter did not depend, as now, upon the caprice of individuals; he was the property of the nation; he was employed by countries and by cities; and his rewards were considered as a just portion of the national expenditure. The educated and the high-born were brought up with a conviction of the propriety and justice of this principle; and when they became members of the government, considered this as useful a method of public expenditure, as squandering thousands on matters merely diplomatic, or in vain shows, mummings, and pageants. And such will yet be the system of our own country, when the people become fully instructed, and are made sensible of the moral and commercial influence of painting.

When we reflect upon the money spent in England by the government, and the consequences which so often attend that expenditure, and when we find in Greece the different results of the same interference on the part of the state, and that the works there produced have been canons of beauty to the world ever since; it is natural to inquire, what was the system by means of which genius was so successfully rewarded? The secondary causes must have been, the competence of the tribunals to which poets, painters, musicians, sculptors, historians, wrestlers, boxers, and philosophers with such confidence appealed. It must have been the taste and

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[1] See a beautiful passage *De Legibus*, lib. ii. p. 669.—If every scholar would mark and transcribe every passage relating to art, a code might soon be made out.

knowledge of the members which composed the judgment-boards, and their sincere conviction of the importance of their office. One has only to sift for a moment the nature of their greatest tribunal, that of the Olympian games; one has only to reflect on the deep feeling, the solemn sincerity, the awful piety of their conviction, that what they had to do involved the future prospects of the rising youth of Greece, and that on their moral honesty depended the glory of their country, and that of its painters, sculptors, architects, philosophers, poets, and heroes. Before proceeding to detail the rise and progress of Greek art, and Greek artists, as the painting of every nation is connected with its civil, religious, and scientific institutions, (though more must always depend on highly-gifted individual effort to advance the knowledge of mankind, than any given assemblage of inferior individuals;) a rapid examination of the principles which guided the decision of one of their most important tribunals, composed of the greatest men the world has seen, ought to form a portion of every history of the art.

Olympic tribunal.

Aristotle in his *Politics*,[1] as quoted by Mr. Hamilton in his pamphlet on the Houses of Parliament, observes: "All were taught γραμματα or literature, gymnastics, and music, and many την γραφικην, or the *art of design*, as being abundantly useful for the purposes of life, but mainly because it enables us to appreciate the merits of distinguished artists, and carries us to the contemplation of *real beauty*; as letters, which are the elements of calculation, terminate in the contemplation of truth." A people thus educated, to understand the basis of beauty in art, and to believe that their decisions, when they became judges of genius, involved their own intellectual taste and repute, and who gave their decisions in the presence of kings, philosophers, and people, were as little likely to be biassed by unjust predeliction as human nature could be; though, of course, in the corrupt times of Nero and the emperors, great abuses took place. But in the Marathonian period, if ever partiality was banished from human honours, it was banished from the Olympic games, in those immortal days of glory and patriotism. At this extraordinary assemblage, kings entered the lists, and nations respected the judgment, or if they refused to abide by the decision of a just tribunal, they were excluded by vote till they paid the fine and acknowledged their error. And what was the result? The highest honours were obtained in these contests, because every one gifted in art, poetry, music, or physical strength, knew that if he deserved the olive-crown, no partiatily, no nephew of the judge's sister, or first cousin of the judge's wife, would deprive him of his due. Every being did his best, and if that *best* failed, he had a consoling conscious conviction that he had been honourably, and honestly, and nobly beaten by a better. It is astonishing, if once entire confidence exist between judge and competitor, to what a degree this confidence affects both; what a spring it gives to mind and body, and how honestly every thing is done: And if confidence be, from repeated experience, withheld, it is wonderful how half the faculties of the mind, and the powers of the body and soul, sink under the impression. Napoleon used to say, "that if the moral feeling of an army was in favour of a campaign, it was equal to 40,000 men." If moral confidence be lost in such cases, disgust is generated, and apathy, indifference, and failure are the result.

In order to understand the Greek character thoroughly, the system of excitement that was worked on, and the materials that were used to rouse the energies of competitors, it will conduce to the understanding of the secondary causes of their perfection, if the nature of the Olympic games be examined.[2] They are universally acknowledged to have subsisted before the rise of chronological dates and records; and the record of the Olympic conquerors after their restoration, is the first known chronological date. Pausanias says they were celebrated every five years, that is, they were celebrated on the fifth year after the fourth had passed; and Sir Isaac Newton is of opinion that they were originally instituted in celebration of victories. Why the Olympic games had always the preference, there is no knowing; but the grand statue of Jupiter at Elis, must no doubt have had considerable influence.

The privilege of presiding at the Olympic games was attended with such dignity and power, that the Eleans who had been in possession of it from the earliest times, were more than once obliged to maintain their right by force of arms. After various disputes about the number of presidents or hellenadicks, they remained at the original number of ten; and Pausanias says, that for ten months preceding the games, they dwelt together in a house appointed for them, and called from them, hellanodiceum. By the most scrupulous attention, they did every thing to qualify themselves for being deservedly the judges of *all Greece;* to which end they were patiently instructed by officers called guardians of the laws, and they attended every day in the gymnasium, upon the preparatory exercises of all those who were admitted as candidates, and who entered their names also ten months before, and exercised during a part, not the whole, of this time, in preparing themselves for the combat. Being exposed to the severest scrutiny, the judges had by these means frequent opportunities of trying the skill of the combatants, and also of exercising their own judgment; and both prepared themselves for the praise or censure of an awful tribunal, and a numerous assembly, whose censure could only be escaped by the most exact impartiality on the part of the judges, and the most sincere and earnest efforts for superiority on that of the competitors. In addition, the judges swore a solemn oath before the statue of Jupiter, upon their finishing the examination, to act according to the strictest equitiy; and to all these precautions against human frailty, liberty of appeal to the senate at Elis was allowed to any one who felt aggrieved. The judges had also the power of excommunicating whole nations. Once an Athenian found guilty of corruption was fined, and refused to pay. The Athenians sanctioned his refusal, and were instantly excluded from all the games, till they repented and paid the penalty. When the Lacedæmonians were impertinent, other nations took up arms, and compelled them to submission. Such power had a wonderful effect on all the nations of Greece.

As the time approached, the candidates were rigorously examined as to their virtuous descent, and their own moral life; and when they passed in public review down the stadium, a herald demanded with a loud voice, "Is there any one who can accuse this man of any crime? is he a robber? is he a slave? is he wicked or in any way depraved?" Themistocles once stood up at the ceremony and objected to Hiero, king of Syracuse, because he was a *tyrant*, a name odious to the democracies of Greece; and there could not be a stronger evidence of their utter detestation of the name, than refusing to admit a king to contend because he was a tyrant; thus placing him upon a level with a slave, who could not by law be admitted. The candidates having passed in public review with honour, were then sworn, that they had done all which was required by law; and marching to the stadium, attended by their friends, connexions, and families, who encouraged them to do their best, and appealed to the gods to smile on their exertions, they were left for the fight. And being thus thought worthy of the contest, even defeat was considered by them as an evidence of their honour. The olive crowns and palm branches were placed before their eyes on beautiful tripods, to excite their utmost exertions, and when victorious it was announced by proclamation; they were crowned by the heralds, and then led along, preceded by trumpets, their names being shouted aloud throughout the vast assembly; and on

[1] Lib. viii. c. 31.

[2] See West's *Pindar*.

Painting. their return to their native city, they entered through a breach in the wall, drawn in a chariot. And such was the high feeling engendered by these judicious excitements, that even Alexander himself was refused permission to contend, because he was a barbarian, nor was he allowed until he had proved his ancient descent at Argolis.[1] "In the republic of the fine arts," says the catalogue to the designs for a National Gallery, "competition is the great source of excellence; but so to frame institutions, and invite competition as to secure all the attainable talent, and so to form a tribunal as to derive all benefit for the public, and to do justice to the competitor, have been matters of great difficulty in all ages and all countries."

The whole history of ancient art shews the estimation in which the unsophisticated judgment of the public was held. Aristotle[2] says, "The multitude is the surest judge of the productions of art;" "If you do not get the applause of the public," says some one else, "what celebrity can you attain?" and Cicero[3] makes the public the supreme judge. Thus then, no one ought to wonder at the perfection of Greek genius in every thing, stimulated as it was by these secondary causes, and the one acting upon the other, in a climate adapted in every way for comfort, for health, and for convenience. The Greeks were men like ourselves, not larger as their arms prove, and not handsomer, for there exist as fine forms in either sex, in Great Britain, as ever graced the atelier of Zeuxis; indeed Cicero complains of the plainness of the Athenians. When genius and secondary causes unite, as they sometimes do, then such men as Pericles and Alexander, and Polygnotus, Zeuxis, and Apelles, are the result; for all the Olympic games, and Greek tribunals, could never have made Hudson Apelles, nor Caligula the benevolent Howard. "If any thing were wanting," says Flaxman, "to convince us of the high estimation painting was held in by the Greeks, the facts alone, viz. that Plato studied it, and Socrates was a sculptor by profession, are enough. But nothing is wanting."

In ancient painting, we certainly owe more to Pliny than to any other author; though in point of exquisite tact for hitting at once the characters of the great geniuses in art, he is not to be compared to Quintilian. There is more discrimination in the short account Quintilian gives of the painters and sculptors, than in all the delightful connoisseur chitchat for which Pliny must ever be the leading favourite. Yet certainly his gossip and anecdotes are sometimes underrated by learned critics; for in two instances of gossip, about the partridges and grapes of Zeuxis and Protogenes, and the contest of Apelles and Protogenes very deep principles of Greek form and Greek imitation may be settled. Painting is said by Pliny to have existed before the foundation of Rome in Italy, as illustrated by designs on the walls at Ardea, Lanuvium, and Cœre. This is always mentioned with a sort of doubt by antiquarians, who suspect that to the arrival of Demaratus from Corinth, the father of Tarquin, king of Rome, Italy owes her first knowledge of painting; but it has been shewn that this cannot be so, if pictures were executed in Italy before Rome was founded. Pliny sneers at the Egyptians for boasting of the antiquity of their painting; whereas the Greeks equally deserve a sneer for believing that they had invented design.

Tabular and mural pictures; distemper and encaustic painting

The Greeks painted tabular pictures on wood, and mural pictures on walls. The materials were either encaustic or wax painting, and distemper or glue-painting. In encaustic on wood, they painted with a metal point called *stylus*; in distemper they painted with brushes, and in encaustic on walls they also used brushes. Tabular pictures were prepared with a ground of wax, and the composition was drawn in with a *stylus* or point as we draw upon an etching ground with a needle. At a sale of antiquities in London there was a regular Greek tablet with a wax ground, a stylus attached to it as boys hang slate-pencils to their slates, and a sentence of Greek actually half-cut. The word γραφω being used for painting, design, or writing, makes the instrument the same in either case. This tablet was like a slate; the middle had been planed smooth, and the frame was left round it. The progress of the Greeks is very interesting, and shews how the mind gradually advances to the imitation of reality, and rests impatiently on mere outline, as a representation of nature. After a certain time, the early artists, when they had drawn an outline, ventured to colour it inside with black. This mode of imitation was called σκιαγραφια, and the paintings σκιαγραμματα, or skiagrams, from σκια shade, and γραφω to draw. Our black profiles and whole figures seen in shop windows, are the skiagrams of the ancient Greeks. This was hailed as a great step, and the painter who could fill up a face or a figure with black was regarded as a man eminent in art. After a little came the genius with more extended views, who invented the μονογραμμα or monogram from μονος only, and γραφω, to draw; that is, to define *by line only*, an outline without a shade. Next came the man who had the nerve to try a *positive colour*. Pliny has preserved his name, Cleophantus of Corinth; he ground up a red brick,[4] and therefore the Greeks claimed the invention of colour, although the Chaldæans had painted men red on the walls of Babylon, and so had the Egyptians on their tombs, nearly a thousand years before them. This discovery was called μονοχρωμα, or monochrom, single-coloured from μονος alone and χρωμα colour, and this was their first attempt at imitating flesh.[5] Next came the white ground (the *gesso* of the Italians and lime and plaster of the Egyptians) covered with wax. From one colour, naturally enough came the others; for if brick produced red, earths, burned or natural, would produce other colours, and polychrom, from πολυς many, and χρωμα colour, was formed.

The art having now discovered its materials, soon advanced steadily and gloriously to excellence. "How long the brush assisted only the cestrum, and when it superseded it," says Fuseli,[6] "cannot be ascertained; it cannot be proved, that it ever entirely superseded it, and there is every reason to believe they were always combined." It has been contested that painting was not known in Homer's time, because he speaks not of art; but what would be said of any man who argued that painting was not known in Milton's time, because *he* did not speak of it. Homer speaks of *painting ships*, and Milton alludes to "the *painted stoa*;" but colouring and design must have been known from the shield of Achilles, and the tapestries of Helen and Andromache, if the walls of Thebes and those of Babylon, had not settled the question. Troy was taken 1184 before Christ; but painting flourished in Egypt 1900 years before our era, that is, 716 years before Troy was taken, and 993 years before the era of Homer.

The nature of distemper and encaustic painting amongst the Greeks involves one or two questions interesting to artists. Their distemper was our tempera, and consisted in dissolving colour in water, and mixing it with glue; and though in Pliny, glue is only mentioned once, and that in conjunction with *(tectores)* plasterers, it is evidently to be inferred from the brushes used in its practice, that tempera intensely varnished was the general practice of the tabular painters, and encaustics the exception. On all encaustic pictures, the Greeks put (ἐνεκαυσεν) "burnt in;" and what justified them in doing so? Merely the general application of fire to melt wax, or a particular mode of practice. Was the cestrum or stylus heated, whilst finishing the work, after the wax had been laid on? or was any actual

[1] See *Notes on West's Pindar.*
[2] *De Republicâ*, iii. c. 7.
[3] *De Oratore*, c. 49.
[4] Testa, ut ferunt, trita, Plin. lib. xxxv.
[5] Μονοχρωματα dictum. ibid.
[6] Fuzeli, Lecture first.

Painting. heat applied to amalgamate the colour in the conclusion, which justified such a term? or was the wax actually melted and used whilst boiling? Pliny says, that there were certain colours which would not stand without varnish; and that after they were laid on walls and dry, they were varnished with a mixture of warm punic wax and oil. Every Greek artist had his chafing-dish or καυτηριον; and when the varnish was dry, it was heated by fire from the chafing-dish "usque ad sudorem," *until it sweated*, when it was rubbed with wax candles, and polished with white napkins. This method the Greeks called καυσις[1] or the burning mode; and why might it not be applied as well to encaustic pictures, when finished either on wood, copper, walls, or stone, thus harmonizing and judiciously amalgamating fierce execution or distinct touches, and authorising the word ἐνεκαυσεν being put after the artist's name?

All the artists in Europe know well how often they use a vehicle[2] for a varnish, and a varnish for a vehicle in practice; and hence it is too absurd to doubt for a moment, that any Greek painter who had once used oil and wax as a varnish, would not use it as a vehicle at the first opportunity. Pliny infers, that "ceris pingere," to paint with waxes (coloured) and "picturam inurere," to burn in the picture, were *the same methods*. "There were anciently," he adds, "two methods, one *cerâ*, with wax, and another on ivory with a cestrum; then came a third, boiling the wax and painting ships at once with it, which was a lasting mode, so that neither sea, wind, nor sun destroyed it." It appears from another passage, that the ships were painted in the same way[3] as pictures which were burnt in. "Waxes are tinted with these colours for pictures which are burnt in; a different manner of painting from that employed on walls, but like that (of waxes tinted) employed for painting ships." Were tinted waxes applied hot? From this it may be inferred that they were.

Encaustic painting may be divided into four methods: 1st, mixing the colours with wax, and thinning them at the moment of painting with a liquid; 2d, placing wax in colours on the ivory, distinctly like mosaic, and uniting them by working them over with a heated cestrum; 3d, boiling the wax and using it hot; and, 4thly, softening the whole picture after completion, by heating it with a chaffing-dish or cauterium. Both Pliny and Vitruvius describe this last method of varnishing; and it is curious to contrast their relative descriptions. Pliny is rapid, careless, general, desultory, as if talking at a party; Vitruvius, accurate, mathematical, careful, and architectural, as if every word was a brick, that must be poised and balanced. Pliny says you must liquefy punic wax with oil,[4] and rub it with a candle and napkins. Vitruvius says, after your wall is dry and smooth, liquefy punic wax, *paulo*, a little by fire, then *temper* it with oil. In Pliny the *paulo* is left out, and so is the fire; but Vitruvius guides you to the *degree*, which is every thing in the practice of the art of painting. The *paulo*, therefore, is invaluable; do not boil, but heat your wax, then liquefy it, then varnish, then when dry heat it with a chaffing-dish and rub it smooth. To artists this practice is beautiful, and though oil-painting was supposed to be unknown to the Greeks, this was very near the point, and if used by Polygnotus at Delphi or Thespiæ, would have justified the term *burnt in*, without the use of the cestrum. Painting.

It is not settled by Pliny who first discovered encaustic painting; it is not known, he says, whether Aristides may have invented it, or Praxiteles completed it. But there existed on the walls encaustic paintings by the old painters Polygnotus and Nicanor; Lysippus at Ægina put his name to his tabular works with ἐνεκαυσεν; Pamphilus the great master of Pausias, did not practice it exclusively; and Pausias was the first in this art. Pausias, Pliny adds, repaired the walls of Thespiæ, painted by Polygnotus, but being obliged to use the brush, failed, because he handled an instrument which he was not accustomed to. It appears, however, that the walls of Thespiæ were painted in encaustic by Polygnotus, and with the brush; or Pausias, the greatest encaustic painter, would not have been employed to repair them, nor would he have gone out of the way to use the brush, if Polygnotus had used the cestrum. But Pausias failed, because the brush was not his instrument; therefore encaustic on walls was not worked with the cestrum, as it was on tablets, and the burning in on tablets was not of the same nature as that on walls. That the brush and the cestrum were totally different in practice there is no doubt; but that there was ever a time when the brush was not used in painting is absurd; and Pliny is evidently wrong in saying it was the last method.

It stands to reason that to paint ships was the earliest necessity of navigation. The ark was pitched inside and outside (Gen. vii. 14). Pitch melted is in fact like wax or oil; and how was it to be equally spread over so vast a surface except by brushes? In fact, amongst the Egyptian antiquities imported of late years, brushes have been abundant. Thus the Greeks painted on walls, wood, stone, ivory, copper, and canvass; on walls it was *mural painting*, and on either of the other materials, *tabular painting*.[5]

There is another question which remains to be settled before touching on the great artists and their works: Did the Greeks paint in fresco? The belief has been that they did. Vasari affirms it; but Letronne certainly establishes the suspicion that they did not, except in a few ornamental parts of architecture, and that stucco was more in practice. In fresco the colours are placed on wet mortar, and become a part of it. In stucco the colours do not become a part, and can be separated. Certain colours are destroyed by contact with lime, and yet those colours which fresco would have ruined, *are always found on ancient painted walls.*

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[1] It is clear that *fire* was always an important part in an encaustic painting, because Philiscus painted a painter's room (atelier) with a little boy *blowing the fire*. Pliny, xxxv.

[2] Vehicle, as distinct from varnish, means the liquid you paint with; varnish, the liquid you put over the work, when done, to preserve it.

[3] "Ceræ tinguntur iisdem coloribus, ad eas picturas, quæ inuruntur; alieno parietibus genere, sed classibus familiari."

[4] That Reynolds introduced wax into British art from this passage, there is no doubt.

[5] At this moment there is a dispute raging in France and Germany whether tabular painting was or was not the principal practice of the ancients, and whether mural painting was ever practised to any great extent. Letronne says cloth was not used *anciently* to paint on, and that Pliny thinks the man mad who painted Nero on cloth one hundred and twenty feet high; but the madness insinuated does not apply to the *cloth or canvass*, but to the *absurdity* of a portrait one hundred and twenty feet high in cloth. Why should canvass be only *once* used in antiquity, and never before or after till the middle ages? Is this likely? As a curious specimen of the blind violence of party, the friends of one of the combatants, Letronne, have written him from Athens, that in the temple of Theseus they have discovered by candle-light round the upper part of the wall, *actual contours* of the works of Polygnotus *cut in on the plaster with the cestrum*, the colours having been picked out by the early Christians; thus proving that Letronne is decidedly right as to his theory of painting on walls. Yet would it be believed, that the friends of his opponent, Raoul-Rochette, have also written him that they *do not see a single contour cut in*, but that they have discovered a *sinking in* of the plaster as if fitted to receive tabular works which were let into the walls; and thus the theory of Raoul-Rochette, viz. that pictures were scarcely ever painted on walls, but nearly always on wood, *is right*, whilst the former gentlemen assert that there are contours on the walls. But the theory of M. Letronne *is also right*; for the ancients painted on walls as well as wood; and though Pliny says that the greatest glory was obtained by easel pictures, he affirms that there were also pictures on walls, because in giving one of his reasons for preferring tabular pictures, he says pictures on walls cannot be saved in case of fire, *(ex incendiis rapi non possunt)*, and that he prefers tabular pictures. If pictures had not been painted on walls as well as on wood, how could he have illustrated his preference?

Painting. Letronne says, that there does not exist a well authenticated evidence of fresco, except as mere ornament in ceilings.

Having thus laid before the reader the different modes of Greek practice, without which no subsequent account of their arts or artists would have been intelligible, it is time to say something of the artists themselves, who practised these various modes of imitating nature. Of their different methods, their white grounds descended to them from the eastern nations, and have come to us through the middle ages. Some of their colours we use now, and for some we have substitutes as good. If their principles were as easily attainable as their colours, we should have very little to desire.

Ancient Greek artists. In the earliest state of Greek art, Philocles from Egypt, and Cleanthes from Corinth, were the inventors of outline, and Ardices from Corinth, and Telephanes from Sicyon, the first who put it in practice, without any colour. To this early period may be applied the accusation of Ælian,[1] that the artists were obliged to write underneath their wretched illustrations, "This is a bull, this is a horse, this is a tree." The next were single-colour painters, or monochromatists, as Hygiomon and others. Now the sexes began to be distinguished, when Cimon the Cleonean had energy to attempt the imitation of every thing. He it was who invented fore-shortening, and drawing things at an angle.[2] He it was who had courage to vary the characters and forms of heads, to make them looking up, looking down, and looking behind; he articulated his joints, shewed the veins and muscles, and gave undulation and folds to his draperies. Panænus, Phidias's brother, painted the shield of Minerva at Elis, and also the battle of Marathon; and so much had the knowledge of colour and art advanced, that portraits of the great leaders, Miltiades, Callimachus, and Cynegyras, on the part of the Greeks, and of Datis and Artaphernes, on that of the barbarians, were introduced, and known by the spectators. It was at this period that the glorious contests for victory in art were begun at Corinth and Delphi; and Panænus was conquered by Timagoras of Chalcis, who commemorated his victory by a poem; "though I doubt not," says Pliny, "there is some chronological error."

The Greek national and monumental painter Polygnotus, flourished at this period or before it. He seems to have been really a great man, and to have possessed a mighty soul. He was born in Thasos, an island in the Ægean Sea; and his works seem all to have been national, votive offerings of cities and his country. He was worthy of the finest period of Greece, and met his noble patrons by a suitable return; he was one of those beings who are born for the time or beyond it, and of whom the time is in want, or for whom it is not enough advanced. He first clothed lovely women in light and floating draperies, adorned their beautiful heads with rich turbans, and thus advanced the art immensely. In expression of face he ventured to make the mouth of beauty smile, and thus softened, by shewing the teeth, the ancient rigidity of his predecessors. He painted gratuitously the Hall at Delphi, and the Portico at Athens, called Ποικιλη, thus offering a contrast to Micon who was paid. Such conduct was immediately judged worthy to be commemorated by the highest authority in Greece, the Amphictyonic Council, who ordered that Polygnotus should henceforth be maintained at the expence of Greece. Pliny has certainly not said enough of Polygnotus, whose great work at Delphi, described by Pausanias, proves him to have had colour in a high degree, imagination in the highest, and all which, according to Aristotle, forms the most important requisite in the language of painting. His work at Delphi was executed by order of the Cnidians, who had a treasure there, and had also built a stadium. Besides this building, they employed Polygnotus to adorn the great Hall, leaving him the choice of subjects; and as Neoptolemus, the son of Achilles, was murdered and had a tomb near the spot, these subjects related to the Trojan war. Painting.

It is supposed that because Pausanias describes one thing as above another, composition was little known, and that there were several subjects in one plane. But any one might describe the Cartoons at Hampton Court in the same way, and make a reader, who had never seen them, believe that one figure was above another, and several subjects too. Might not one say, "*Above* Pythagoras in Raffaelle's *School of Athens*, is Alcibiades listening to Socrates;" but because they are *above* one another, that is no proof that they do not *retire*. Aristotle settles his high rank better than Pliny or Quintilian. "Polygnotus," says he, "made men *better* than they are, Pauson worse than they are, and Dionysius the same as they are."[3] Polygnotus, therefore, expressed the leading points of the species man, and cleared the accidental from the superfluous. Cimabue did not do this, nor Massaccio, nor Giotto; but Raffaelle and Michel Angelo did; and when this is done, in painting or sculpture, the component parts of art must be equally advanced. Besides, when did Polygnotus flourish? Between the 84th and 90th Olympiad. The Parthenon must have been built; the beauties of Phidias's immortal hand must have been executed, such as we see them in the Theseus, Ilyssus, metopes and friese of the Elgin marbles. And could any painter be a Goth in composition, when such knowledge of the art is visible in these perfect wonders? Polygnotus put the names to many of his figures; Annibale Caracci put "genus unde Latinum" to Venus and Anchises; Raffaelle gilded his glories; but what argument is that against the genius of either? The power of Polygnotus in painting the dæmon Eurynome, with a skin the colour of a blue-bottle fly, shews the truth of his imagination, as well as his power of observation and imitation. Polygnotus was a great genius, worthy of his age; and the "simplex color," applied by Quintilian to his works, only proves the purity of his taste in using it.[4]

Simplicity is not barbarism, any more than gorgeousness is true taste. About the 90th Olympiad the light began to dawn and to give promise of a glorious sunrise. Aglaophon, Cephissodonus, Phrylus, and Evenor, the father of Parrhasius, and preceptor of the greatest painters, appeared. These were all celebrated in their day; but one of the most important reformers was Apollodorus the Athenian, who flourished in the 93d Olympiad. He was the first, according to

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[1] Ælian, lib. x. chap. xii.

[2] Catagrapha invenit, hoc est, obliquas imagines et varie formare voltus, respicientesque, suspicientes vel despicientes. Fuzeli says *catagrapha* means *profiles*; but how could he *invent* profiles when *profiles* are the characteristics of the *earliest* art? At first all art is profile; but Cimon was a reformer. To draw downwards he invented oblique views, and varied the views of the head and face, looking behind, looking up, and looking down. Fuzeli says *catagrapha* means profile; but profiles are not oblique representations but sections of the figure and face, in the same sense as architectural sections, that is, equal halves. The "obliquæ imagines," are *angular views*, seeing things at an angle; the passage is directly illustrated by the circumstances, that he made his heads looking behind, &c.; and how can a head looking behind be a *profile*? In some places it may mean so; in Pausanias, κατα in radical meaning is *downwards*, as if the eye looked at the top of the head to the feet, which is *fore-shortening*.

[3] Aristotle, *Poetics*.

[4] Hardouin's *Pliny*, lib. xii. c. 10, p. 893. Clari Pictores fuisse dicuntur Polygnotus, atque Aglaophon; quorum *simplex color* tam sui studiosus adhuc habet," etc. Now the *simplex color* of Polygnotus and Aglaophon was not *one colour*, like monochroms, but modesty in the arrangement of the *three* colours, red, yellow, and black, without blue. How then could the monochrom apply to Polygnotus, whose works at Thespiæ, Delphi, and the Poikile at Athens, were painted in all the variety these three colours could produce, and not confined to *one* colour?

Painting. Pliny, who expressed the *species;* and he was also the first who did honour to the glory of the pencil. But, after Phidias, Panœnus, Micon, and Polygnotus, one is inclined to question whether he was the first who expressed the species. Phidias, in the opinion of the ancients, was the greatest artist in sculpture. Plato says that Phidias was "skilled in beauty;" but to be skilful in beauty, argues the power of expressing the species, and a perfect knowledge of the construction; for beauty is the last operation, and is based upon the first. How then Apollodorus could have expressed the species better than Phidias or Polygnotus, it would perhaps have puzzled Pliny to explain. However, let us take what the gods have spared, and be grateful. "His, is the adoring priest," says Pliny, "and Ajax defying the lightning at Pergamus; nor was any tablet worth looking at before." That may be. The previous works were monumental, national, or mural, painted with brushes, and bold in execution. Tabular painting may have been a more delicate workmanship; but it is not to be compared with the true epic, any more than the highly-wrought easel pictures of Raffaelle, are to be compared with his frescos.

Ancient Greek painters. "The doors," says Pliny, "that Apollodorus had opened, Zeuxis boldly marched through, about the 95th Olympiad; daring every thing the pencil could do, and carrying it to the greatest glory." Some place him in the 89th Olympiad; but this is a mistake. Demophilus or Naseas was his master. Apollodorus became envious of Zeuxis, because the latter improved upon the style he had introduced, and wrote a lampoon. Zeuxis became very rich, grew very haughty, and always appeared at the Olympic games in a purple robe, with his name in gold letters on the border. So high was his opinion of his own pictures, that, thinking no money could equal their value, he gave them away. From this feeling, he presented an Alcmena to the Agrigentines, and a Pan to Archelaus; he also painted a Penelope, in which her moral beauty of character was visible, and an athlete, so much to his own delight, that he wrote underneath, "It is easier to criticise than to execute." His great works were Jupiter and all the gods, and Hercules strangling the serpents. He was censured for large heads and violent markings, but otherwise he was strictly correct. Pliny varies his history with current stories, and we can almost get at the principles of Greek art from them as well as from the account of the art itself. Current stories and proverbs should never be disregarded; for, if not true, they may be taken as inventions characteristic of the parties, or they would never have been believed. The Agrigentines, says Pliny, ordered a picture for a temple of Juno Lucinia, and they allowed the painter to select the finest girls as models. Cicero[1] says it was the Crotoniates who employed him; and as Zeuxis always studied nature, the most beautiful girls were ordered by government to come to him, and having selected five, he then painted his Helen. Zeuxis made his sketches in black and white (*pinxit et monochromata ex albo*) or of a single colour heightened by white. His contemporaries and rivals were Timanthes, Androcydes, Eupompus, and Parrhasius. The contest of the last with Zeuxis, in which the one deceived the birds by grapes, and Parrhasius Zeuxis himself by his curtain, contains the great principle of Greek art, viz. *That the most perfect imitation of reality was not incompatible with the highest style.* Antiquaries are disposed to laugh at these stories as beneath the dignity of belief; but artists know well enough, that, so far from being unworthy of credit, all the stories of Pliny and Ælian tend more or less to illustrate a principle. Zeuxis painted a boy and grapes, and the birds flew at the fruit; but his rival observed that, if the boy had been equal to the grapes, the birds would have been frightened. Zeuxis was a great painter and discovered the principles of light and shadow.

After Zeuxis came Parrhasius, "liquidis ille coloribus,"[2] who was born at Ephesus, and celebrated for great excellence. Painting. He first gave correct proportions to painting; airs to the head, elegance to the hair, and beauty to the countenance. By the acknowledgment of all artists, the manner in which he *lost* the contours of his forms, was exquisite. Many people can execute the parts of which the middle of things is composed; but few can finish the boundaries of objects as if the substance was round, and did not end with the contour which defined it; thus giving one an idea as if something was concealed, and exciting the imagination to conceive what the eye did not see. This excellence Xenocrates, and Antigonus, who wrote on painting, conceded to Parrhasius; and not this excellence alone, but also many others. The best idea than can be given to the moderns of the works of Parrhasius, is by referring them to the pictures of Corregio, of which this is the great excellence. Parrhasius appears also to have had the same defect; for he softened the centres of his figures, and gave them too much pulpiness for the heroic. There remained, in Pliny's time, sketches of subjects, and of hands and feet, from which artists learned a great deal. He contrived in a picture to paint the people of Athens, and to give a true idea of their variable character; humble yet vain-glorious, timid yet ferocious;—and all these contrasts he expressed with great power. But Parrhasius disgraced his genius by yielding to what Johnson calls "the frigid villany of studied lewdness," and sacrificed his noble art to pander to the beastly appetites of the debauched; in fact, Tiberius kept one of his licentious pictures in his bed-room, namely, that of Meleager and Atalanta. But whatever may have been the habits of antiquity, and however indecencies may have been connected with religion, it is clear the greatest men did not approve of such prostitution of talent. Aristotle censures the practice, and warns tutors to guard their pupils from such corruptions.

Timanthes followed, the great painter of the sacrifice of Iphigenia in Aulis. No picture had more reputation for touching art and delicacy than this. After exhausting expression in all the principal agents, the artist covered the face of the father, not daring to trust his hand to attempt imitation, and leaving every spectator to imagine an agony of his own. As Euripides has the same incident, Fuzeli thinks the honour of being the first inventor is due to Timanthes. In the death of Germanicus, Poussin hid the face of his wife. Timanthes seems to have been ingenious in his inventions; to give the idea of great size to a sleeping Cyclops, he introduced two satyrs trying to span his thumb. Pliny adds, that there was a head painted by him in the Temple of Peace at Rome, and which was a perfect specimen of art.

Euxenides taught Aristides, the great master of expression, and Eupompus taught Pamphilus, who was the master of Apelles, a name synonymous with perfection in finish, but not for invention like Zeuxis, monumental commemorations like Polygnotus, composition like Amphion, or expression like Aristides. No; Apelles was the deity of tabular pictures, the greatest glory of the art in Pliny's mind, but not in the minds of those who see beyond the range of a dining-parlour. Eupompus painted a victor with a palm branch in his hand; and such was his influence in Greece, that he was allowed to divide painting into three schools, viz. the Ionian, Sicyonian, and Athenian. Pamphilus was a Macedonian, who combined literature with painting and made it a principle of tuition, that no man could be great in either who was not a mathematician; for he denied that without geometry art could be perfected. He taught nobody under a talent, which both Apelles and Melanthus paid. So great was the influence of this distinguished man, that first at Sicyon, and afterwards in all Greece, he got it established as a principle of education, that all clever boys should be taught on tablets the art of delineating, which is the foundation of

[1] De Invent. lib. 2, chap. x.

[2] Horace.

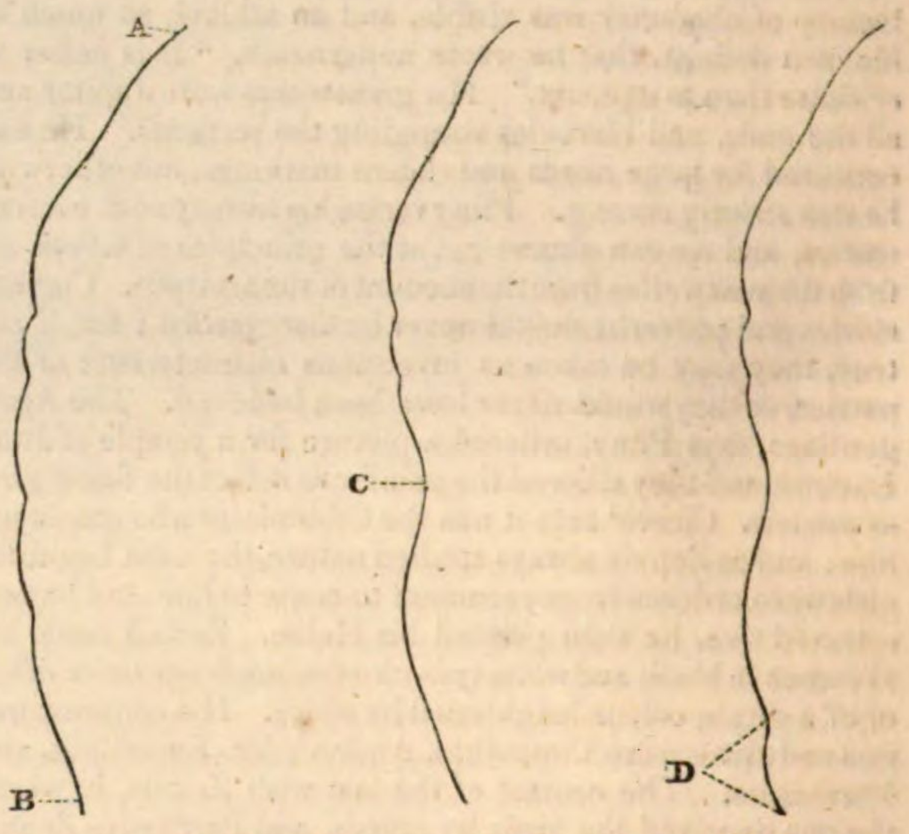
Painting. painting. He considered this art as the first that should be taught in a liberal education. Slaves were prohibited the exercise of design; which was an absurd law, because in literature it would have prevented Æsop or Terence from developing their genius. What right have any creatures, who are obliged to eat and sleep like the meanest slave, to pass a law to prohibit the exercise of any natural talent, if the Almighty has not disdained to think one worthy of being so gifted? The consequence of this was, that no slave ever distinguished himself in the arts.

About the 107th Olympiad, after Echion and Theramichus, came the god of high finish and grace, Apelles. His style is always the precursor of decay. First came a race in art, amongst whom invention, expression, form, colour, and execution, in a series of pictures intended to illustrate a principle were enough, provided the principle was expressed. These were the *monumental geniuses*. But when the art becomes national and glorious, the noble and the opulent become ambitious to share the glory with their country; and the art sinks to the humble office of adorning apartments. As is the demand, such will be the supply; and the genius of a country is thus turned from national objects and public commemorations to private sympathies and domestic pleasures. At this period of Greek taste appeared Apelles; refined, accomplished, delicate, devoting his whole soul to single perfections equally adapted for a temple or a palace, and patronised equally by his sovereign and the people. Educated by Pamphilus, he was grounded to the very foundation, and consequently drew, as Burke says to Barry, with "the last degree of perfection." Apelles, Aristides, Nichomachus, and Protogenes, were the most distinguished artists of Alexander's time.

Apelles wrote copiously on his art, and explained its principles. His treatises were extant in Pliny's time, and even in that of Suidas,[1] who speaks of them; and as they were probably illustrated with designs, the loss is much to be deplored. Beauty was the leading feature of his style, as well as of that of the greatest painters of the same period. In grace he defied competition; and this explains the secret of his triumph. "I know when to leave off," said he, "which is a great art; Protogenes does not. Over-working is injurious." He was a very generous man, and acknowledged when others were superior to him; observing that Amphion[2] was a better composer, and Asclepiadorus more correct in proportion. Amongst all the stories of Pliny, the most delightful is that of Apelles and Protogenes, which seems to be an authentic fact; and even if it were not, it would illustrate the principles of Grecian art. Protogenes lived at Rhodes and Apelles sailed to see him. Having landed, he called, and found the artist "not at home." Being shewn by an old woman into his painting-room, he found a tablet with its wax ground ready for a picture, and taking up a brush, drew an exquisite line in colour down the tablet. Protogenes having returned, was shewn what had happened; and, contemplating the beauty of the form, he said it must be Apelles, as nobody else could draw so perfect a work. He then took the brush and drew another still more refined, saying, if the stranger call again, shew him this, and say that that is what he is seeking. Apelles returned, and blushing to see himself outdone, again took a brush and drew a third, leaving nothing to be exceeded in refinement, *(nullum relinquens amplius subtilitati locum.)* Protogenes when he saw this immediately sought his visitor, saying that he could carry the line no further. The tablet with these lines upon it, was considered by all the Greek artists as a miracle of drawing. After the death of Apelles and Protogenes, and the conquest of the Romans, it was preserved in the palace of the Cæsars on the Palatine hill, where it was seen by Pliny containing nothing but three fleeting lines, *(tres lineas effugientes)* and yet superior to all that was to be found in the finest works. Unfortunately it was burned at the destruction of the palace. Painting.

Now comes the question, what were these lines which could thus speak to artists who had never seen each other, the common language of a common code of law for design. "*Secuit lineas*" does not mean actually to cut the lines in two, but in the technical idiom of English artists, to strike a line. It was not the metal cestrum, but the hair brush, and therefore *cut* in this sense could not have been meant. To *cut* with a brush means to design with an air of power. Three lines varied in shape would mean nothing, if nothing was expressed; but if some known contour of the body was taken in repose, three variations of its position without alteration would be as much as could be expected in the contour. Suppose that Apelles drew a line from the clavicle A to the pubis B of a body in profile, shaping all the parts as he went correctly like fig. 1. Next, suppose that Protogenes having come in saw the line, and knew that in finely-formed men, the stomach, from great exercise and temperate living, becomes small; the contour would curve in at C, so that that portion of the *rectus* muscle would retire, as in many of the Greek statues. He would then take the same contour, draw it again on the wax tablet, and make this variation. Again, suppose that Apelles returned and on seeing himself vanquished, took the brush and drew the same contour, allowing the variation of Protogenes, but remembering that in powerful men, the *pyramidalis* D, fig. 3, arising from the *pubis* and going into the *rectus*, makes another and the last variation. Then Protogenes returning, and seeing that nothing more could be done unless the body was altered in position, he would acknowledge the line to be completed.

Fig. 1. Fig. 2. Fig 3



In Conduci's Five Dialogues, it is stated that Michel Angelo thought it must have been a contour of some part of the body. Now. this singular contest would be felt by all artists as one of the greatest utility. It would be wondered at by connoisseurs, and would illustrate a great principle; namely, that a knowledge of construction was the basis of correct design and the foundation of all beauty.

It was the continual practice of this eminent man to do something every day, whatever happened; and hence the proverb, "No day without a line." If artists were to write

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[1] About the year 1100 of our era.

[2] Junius *(de Pictura Veterum)* only finds Amphion mentioned twice in ancient authors, and it is hence supposed that Echion would be a better reading.

Painting. this over their painting-room doors, it would not be without advantage. Rubens rose at four, and was in his painting till five in the afternoon, with occasional variations. All the greatest men of antiquity and of modern art, have been the most diligent and the most industrious. And here is the most celebrated of the tabular painters of antiquity afraid to let a day pass without the use of the pencil. Apelles used also to hide himself behind his works to hear the remarks of the public. This deference to the public voice evinced by sculptors, painters, and statesmen, is a beautiful proof of the sense and understanding of the time. Nothing was done in defiance of public taste, but every thing in conformity to its dictates; and though this does and often did lead to great injustice in political matters, in art the maxim is infallible.

Apelles of Cous excited envy enough, and notwithstanding his graceful manners, his tender heart, and his accomplished mind, when driven by stress of weather into Alexandria, the courtiers of Ptolemy, hating his superiority, and fearing his probable fortune, sent him a pretended invitation to sup with the king. Apelles went; the king felt astonished at the liberty, and sending to demand explanation, discovered the imposition. On inquiring if Apelles knew the person who had given him the invitation, he immediately sketched his face on the wall, and the king recognised the culprit. Courts, kings, and people can only judge of results. The infinite number of repeated acts, the *nulla dies sine linea*, the failures, the recoveries, the musings, the thinkings, that had taken place with the "cestrum cum lumine," they had not witnessed; therefore, knowing their utter incapacity to do as Apelles did, they concluded that he was a wonder, and he of course became a favourite. As an evidence of that peculiar tact by which such men are sure to please kings and nobility, namely, by the power of seizing the most agreeable expression of any sitter's face, however ugly, and rendering his very defects a cause of elegant concealment; he painted Antigonus, who had lost one eye, in profile, concealed his defective eye, and made him as graceful as if he were Alexander. This was the great secret of his fortunes, as it was that of Titian's, Vandyke's and Reynold's; and though not to be compared in point of taste or knowledge of the art, this was also the secret of the popularity of Lawrence, mere portrait painter as he was, and nothing more.

Polygnotus, Pausias, Aristides, Timanthes, Zeuxis, Parrhasius, Pamphilus, Euphranor, and Timomachus did not so completely gratify the vanity of their contemporaries, and were not such personal favourites as Apelles; for there is no gratitude equal to the gratitude of being successfully painted. Kings bow to the unknown power of having their momentary expressions observed, seized, transferred, and fixed for ages, and whilst colours and canvass last, carried on, for the admiration of a distant age, when the existing one is past and forgotten. What can equal the gratitude of a woman to have her beauty preserved, whilst she is in her bloom, for the admiration of her children when age has shrivelled her form, or misfortune destroyed her happiness? The world may be elevated, excited, roused, by the commemoration of the great deeds of ancestors or heroes; but no sympathy is ever excited, and no personal vanities are ever so happily gratified by any class of painters, as by the great portrait-painter. The degree of imagination required is not of that irresistible kind which forces him to leave the model before him, using it only to realise his own burning conceptions, so that all likeness of the *individual* is lost; he requires no more than to retain in his mind the best expression of the individual before him to identify it upon canvass. But it must be exactly like, or it is nothing. After the likeness is completed, the sitter will have no objection to the highest degree of embellishment. There the great portrait-painter shews the degree of *fancy* wanted, and he that embellishes most, without losing resemblance, will be the most welcomed, as Apelles was, by the world. Painting.

To put Apelles in comparison with Polygnotus is out of the question. Highly-wrought individual figures, little more than portraits of beautiful nature, cannot rank so high in the judgment, though they may in the delicate sympathies of the world. But that single terrific conception of the demon Eurynome, for which no prototype in nature could be found, that momentary blush which crimsoned his Cassandra,[1] Aristotle's praise that he made men better than they were, and Plato's ranking him with Phidias, settles the question of his greatness; and as a portrait expression must be seen before it can be done, and must be like or it is nothing, there is an end of the highest quality of human genius, invention. Indeed, whatever the vanity of the world may be inclined to feel, the greatest portrait painter is but an inferior artist.

The age of Polygnotus and Phidias was the meridian age of Greek art; and that of Apelles was the setting glory. From the latter period it sunk gradually as if nature had been exhausted by the previous effort. Such ages have never since been seen; such perfection had never been realized before, and never will be again; for in order to become such sculptors and painters, men must also become idolaters. But to return and conclude the notice of Apelles, this court-favourite of antiquity. Notwithstanding the education of Alexander by Aristotle, notwithstanding that ἡ γραφικη was a portion of his education, Alexander was little more than a glorious barbarian in art. He talked so absurdly in the painting-room of Apelles, that the artist was obliged to request that his majesty would be cautious, lest the boys should laugh as they ground their colours. Apelles may be considered as the Titian of Greek art, with the addition of all that vast knowledge of form, which every painter and every school was obliged to master. But the disposition to perfect single figures, and the acknowledgment that others exceeded him in composition, clearly point out the extent of his fertility. Though Pliny describes many beautiful pictures, his greatest are single figures. His Venus Anadyomene was the most celebrated of all his works; but being painted upon wood, it was destroyed by insects in the time of Augustus. He began another, and having completed it as far as the bosom, died; but although the contours were completed for finishing, nobody would venture to touch it, such was the extreme veneration entertained for him. By this description we see the nature of the Greek process; first, the ground, then the drawing in, next the impasto preparation, and then the completion part by part. He had got the picture finished as far as the bosom; and therefore to finish highly by degrees was his system. He was not deficient in expression, for he painted persons dying with great power. His imitation must have been perfect, for his painted horses are said to have made real horses neigh; and his colour must have been exquisite, for he glazed like the Venetian school. Pliny mentions him as one of those who painted with four colours; but this is a mistake; for it was in the age of Polygnotus that *blue* was not used. From a passage in Cicero,[2] it appears that that age was famous for "form and contour;" whereas, according to the same writer, *all* things were perfect in the works of Protogenes, Nichomachus, Echion, and Apelles.

Pliny is therefore right in saying that pictures which constituted the opulence of towns, were painted with four colours only; but he is not as clear as usual in regard to the period to which this observation applies. Quintilian, calling the colour of Polygnotus "simplex color," seems to indicate the absence of *blue*; whilst *red*, *yellow*, *black*, and *white* did not produce such gorgeous splendour as in the age of Apelles. Thus Quintilian, as well as Cicero, collaterally proves Pliny to be in part right. It is extraordinary that Reynolds did not

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[1] Lucian.

[2] *Brutus*, c. 18.

Painting. allude to the absence of blue in the enumeration of Pliny. Great depth, fine tone, simplicity, and modesty, can be obtained without blue, but never that tremendous magnificence produced by the contrast of the deep and awful azures of Titian. Though Polygnotus did not use blue, his black was made from vine-stalks and wine-lees,[1] which render black more blue than the ivory black of Apelles, which was discovered by him, and is used to this hour in Europe. There were several of the same name, but *Apelles Cous* distinguishes the great Apelles, as *Aristides Thebanus* does the great Aristides.

After this long account of the courtly, accomplished, and highly-wrought Apelles, there may be something interesting to allude to Aristides the "great master of expression," as Fuseli calls him. He was the first who painted deep human emotions, fierce passions, and distressing perturbations; but he was hard in colour, says Pliny, and not so harmonious as Apelles, probably like Raffaelle, the great Italian master of expression, in comparison with Titian. His finest picture was that of a mother dying from a wound which she had received in the sacking of her native city. Her infant was trying to reach the nipple with its boneless gums, whilst the mother, faint and exhausted, appeared struggling to save it from sucking, lest blood might mingle with its nourishment; a tender and affecting thought. Alexander was so touched by this picture at Thebes, when the city was taken, that he sent it to Pella.[2]

Protogenes was another of the great men of this time. It is indeed extraordinary to reflect how genius in art and literature seems always to come in clusters in every country. He was born at a small town on the coast of Asia Minor, subject to the Rhodians; and he got his living till he was fifty years old, in great poverty, painting beautiful ornaments for the prows of ships. He was not a man of fertile invention, and spent years over single works, which induced Apelles to say that he never knew when he had finished. His celebrated work was Talissus, which occupied him seven years. Titian took eight to paint the Pietro Martyre, and seven to finish the Last Supper for Charles V.;[3] and yet in Titian's works there is no appearance of over diligence. Pliny says he painted his pictures four times over, so that if one picture was destroyed another might be ready. Nothing shews so completely the exact degree of knowledge which Pliny had of art as this absurd conclusion from an admirable practice. Protogenes proceeded with his works as Titian did, by *stages;* and each stage was a separate impasto of colour, which helped the next till completed. Of this artist the story is told of his flinging his sponge at a dog's mouth in a rage, because he had vainly tried to hit breath coming out of it, and by that accident succeeding; a circumstance which shews that it was tempera painting, for a sponge would not have done for wax. Such a habit of daily application had Protogenes, that when Demetrius besieged Rhodes, he would not leave his painting-room, but proceeded daily in his studies amidst the noise of battering rams and catapultae. The king came often to visit him; and that part of the town where he worked was spared, and the picture thus finished was said to have *been done at the point of the sword.* Protogenes painted the mother of Aristotle; and the philosopher urged him to execute the battles of Alexander; but he was not a man of rapid conception or fertile invention for a series, and could not be moved.

It is curious to reflect, that all the great painters painted portraits; which proves that they thought it essential to that truth which was the foundation of their ideal beauty. Indeed, every great painter *should paint a portrait a month;* and if, like the Greeks, he has always nature for his works, he never can degenerate into manner. Painting.

Of the other painters, Asclepiodorus was celebrated for proportion; Nicomachus for rapidity of hand, and Theon for wild conceptions, "quas Græci vocant *φαντασιας.*" Pliny places Theon amongst the herd, whilst Quintilian and Ælian place him amongst the illustrious, where he ought to be. He painted a single warrior dashing forward on the spectators; and collecting the public, he kept the picture behind a curtain, when in the midst of a blast of trumpets, the curtain was dropped, and the wonderful figure terrified the people. He also painted Orestes, distracted and insane, and proved himself a great and wild inventor. The three remaining great men of the fine period, were Pausias, Euphranor, and Timomachus. No passage has excited so much discussion as the well known one in Pliny, where he says, "nulla gloria artificum est, nisi qui *tabulas* pinxêre," as if he meant that the only glory in art consisted in tabular pictures, "*πινακες,*" on wood, and that there was but little in monumental and mural efforts. Pliny, however, does not here contrast the tabular pictures of Apelles with the mural paintings of Polygnotus, but with the works of one Ludius, a Roman, a mere ornamental landscape-painter upon walls, like our Bond Street paper painters. This was much the fashion in Pliny's time, which he laments; and many examples of the same species may now be seen in Pompeii.

Having thus described the fancies and caprices by which the art had been degraded, Pliny turns to the highly beautiful tabular works of Apelles, and observes naturally enough; "This is not the thing; the glory of art and of artists consists in the Venus of Apelles, the mother of Aristides, the Ialysus of Protogenes, and not in this mechanical whim, which is not the glory and the end of painting." This, perhaps, is the explanation which he would give if he were alive and able to answer us. Is it not unjust then to take up such ground as M. Raoul-Rochette has done in France, and Payne Knight in England, and infer that there was no real glory in any other mode of painting? The ancients estimated mural painting at Delphi, as the Italians do in the Vatican. But they did not undervalue tabular painting, small pictures, encaustic, landscapes, or humour; they painted in every style and they excelled in all.

Pliny now proceeds to the encaustic painters, of whom Pausias and Euphranor appear to have been the greatest. Pausias was a master of foreshortening, as we learn from Pliny's description of a bull which he painted in front and projecting beyond the tablet. After Pausias came the Isthmian Euphranor, who wrote on symmetry and colour, painted great and small works, and delineated statues and animals. He said of his Theseus, that "it was real flesh, whilst that of Parrhasius had fed on roses." Then came Nicias who painted women beautifully, understood light and shadow, and was another pillar of art. Metrodorus was both a philosopher and a painter; and when the victorious Paulus desired Perseus to send him a philosopher to educate his children, and a painter to arrange his triumph, Metrodorus was despatched as a person capable of executing both tasks. Timomachus is the last of this splendid list whom it is necessary to mention. He died, like Apelles, leaving an important work unfinished.

Glory and decline of Greek art. Such were the most illustrious men of the three finest periods of Greek painting. The first period of Greek art was that before Pericles; the second, or that of Pericles himself, was the finest, the highest, and the purest in painting, sculpture, and architecture; the third was the epoch

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[1] See Pliny, lib. xxxv. The sea in the Venus Anadyomene is quoted as a proof that *blue* must have been used. But where is there any *blue* in Vandervelde? We do not think that a picture exists with *blue* in his sea.

[2] Raffaelle imitated this in his plague, where a fine youth is putting away an infant from a dying mother's bosom; but the utter want of taste in making the boy hold his nose for fear of infection, renders the sentiment not pathetic but at once disgusting and ridiculous.

[3] See, in Ridolphi, Titian's letter to the emperor.

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of Alexander, the most refined, but prophetic of the corruption followed; then came the subjugation of the Romans, when the noblest works of the Greeks were seized as tribute, or matters of right, and Italy was inundated by the productions of Greek talent.

Effects of the conquest of Greece.

This influx of foreign productions entirely suffocated native Italian genius. Greek productions became matters of property; and dealers sprung up who manufactured originals to supply the market of the rich collector. Galleries were formed to produce genius, which had sprung up from national demand without a single gallery or a single collection of any works, except the productions of their native soil. The most celebrated works were copied and re-copied by the Greeks in all parts of the Mediterranean. Horace alludes to this; and there can be no doubt whatever that the effect was to render all native attempts of the Romans and Etruscans no longer available. For not one great artist is named during the whole period of progressive decay from the Cæsars to Constantine; and the Romans or Latins never produced any talent worth consideration till the revival of art in Italy, after so many ages, in the fifteenth century. Then, the same principle operating, and the church and state demanding art as an assistant, outpoured an abundance of native talent, because there was a vent, as there had been before, in Greece, Egypt, and Chaldæa; and the genius of Rome, Florence, Pisa, and Venice, vindicated their long suppressed claims to originality. Amongst the illustrious Romans, Julius Cæsar seems to have been a magnificent collector; but whether, like Napoleon, he was also a magnificent patron of the talent of his time is not known. He bought Greek pictures, and presented them to Roman temples; but one work of native art, produced by native patronage, is more honour both to patron and to artist than a gallery of foreign pictures be they ever so divine.

Upon the whole, before tracing art from its decay to its revival, we cannot but acknowledge as evident, that a period of dearth in genius has generally succeeded in the world to one of prolific production. In painting and sculpture, secondary causes, such as the nature of the government, or the circumstances of the two arts being required for political purposes, may considerably facilitate the development of genius. But it is not so with the poet. He can give vent to his immortal thoughts in poverty or wretchedness, independently of the taste of the times, or the patronage of the state. Milton, in obscurity and blindness, wrote Paradise Lost; and Savage, in poverty and wretchedness, composed his Bastard in the streets, begging bits of paper as he walked, when he had more thoughts than his mind could contain, and thus, as effectually preserved them as if he had been bred in a palace, or had sheets of the finest *hot-pressed* to receive his lucubrations.[1]

Inferiority of the Roman school.

After the conquest of Greece, and the removal of art and artists to Rome, the genius of painting seems to have left the world. The Roman school of painting and sculpture is scarcely worth a single thought. In the last years of the republic the art sunk rapidly. Augustus tried to revive it; but though the pupils and descendants of the illustrious dead attempted to second his views, and though the writings of Apelles, Euphranor, and Pamphilus, were all in existence, and their principles known and acted upon, genius was nowhere to be found. That divine spark with its attendant whisper, unseen but not unheard, which ever attends the gifted who are born for great objects, whether it supported Columbus amidst the storms of the Atlantic, Alexander as he plunged into Asia, Napoleon as he rushed into Italy, Wellington at Waterloo, Michel Angelo when he painted the Sistine Chapel, Raffaelle when he entered the Vatican, or Phidias when he adorned the Parthenon; that supernatural, incomprehensible something, which inspires hope, "when the whole world seems adverse to desert," was gone from the earth like the glory which had blazed in the temple. All that the savage, splendid, imperial Romans could do, all the honours and riches they had to confer, were bestowed in vain. Architecture suited their savage vastness of mind better than painting; therefore architecture flourished, and Augustus was said "to have found Rome thatched, and left it marbled."

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> Not Babylon
> Nor great Alcairo, such magnificence
> Equalled in all their glories, to enshrine
> Belus or Serapis[2] their gods, or seat
> Their kings, when Egypt with Assyria strove
> In wealth and luxury.

Claudius built a superb aqueduct, and Nero burned[3] and rebuilt a golden palace; but he could not replace the lines of Apelles and Protogenes, or the miracles of Timanthes and Aristides, which perished in the conflagration. Galba, Otho, and Vetellius were hurried through life and empire too rapidly for art; whilst Vespasian and Titus bewildered the Romans with their Cyclopean masses. Hadrian, himself an artist, endeavoured to recover art by indiscriminately encouraging Etruscans, Greeks, and Romans; "but such a medley of principle as their works displayed," says Agincourt,[4] "hastened the decay of art, and rendered the emperor hopeless of reviving it." The art thus went floundering on until Dioclesian, with all the gorgeous splendour of an eastern monarch, mingled together Roman, Greek, and oriental art, and corrupting all taste led to its extinction. It was between the reign of Commodus and that of Constantine, that those causes were generated which undermined the empire, and brought art, science, and literature into the chasm. Of forty emperors who, from the second to the fourth century had struggled for the diadem and obtained it, twenty had been murdered by the army and the people. "Ainsi" says Montesquieu "comme la grandeur de la république, fut fatale au gouvernement républicain, la grandeur de l'empire le fut à la vie des empéreurs."[5] Constantine's removal of the seat of empire did not so much begin the destruction of art as complete it; for previous causes, domestic and political, had been preparing the ruin for centuries before.

Age of Constantine.

Agincourt thinks that as far as art is concerned, too much has been attributed to this removal of the empire. But yet the first epoch of what may be called *modern art* in opposition to *ancient*, must date from the introduction of Christianity as a state religion, when the whole moral feelings of Greek and Romans took another turn in painting and sculpture. Although Constantine only grafted Christianity on Paganism, and founded more catholicism than Christianity, by meeting and uniting the prejudices of both Pagans and Christians; yet surely if genius could ever be created by patronage, the age of Constantine, and those of Charlemagne, and Louis XIV. ought to have rivalled those of Pericles and Julius. Such was the rage for splendour in this reign, that the quarries of Phrygian marble and of the isle of Proconnesus, were almost destroyed to furnish palaces for the emperor, his sons, and his ministers. Temples, palaces, forums, triumphal arches, colossal statues, an hippodrome, and eight public baths were built and adorned at once; and in addition, splendid commissions were given to the painters for pictures of Christ, the Virgin, the prophets, and the apostles. Rome, Naples, Capua, Antioch, Tyre, Jerusalem, and even Bethlehem, felt the effects of this mag-

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[1] See Johnson's *Lives of the Poets*, art. Savage.

[2] In this beautiful passage, the immortal author has made the penult syllable of *Serapis* short, whereas it is in reality long, *Serāpis*; an error which could scarcely have been expected in one who was a great scholar as well as a great poet.

[3] Tacitus does not seem altogether to believe it. [4] Agincourt, *Histoire de l'Art*, tom. i. [5] *Décadence des Romains.*

Painting. nificent employment; but what were the results to painting? Nothing, absolutely nothing, to guide anybody except the antiquary; and if any evidence were wanting to show that the genius and the patron must exist together, or the result will be nothing, the end of Constantine's splendour would abundantly supply it.

The moral character of ancient Greece was gone; the instinct of public glory was passed; their olive crowns, the adequate reward of talent on a great principle, were sneered at; and "Lucian," (as the author of the *Discours Historique* observes) "had already ridiculed this tribunal," which had listened with rapture to Herodotus, and crowned Aëtion for a fine picture, and which in its days of Marathonian glory, had done more than ever was done before or since in rousing human effort, mental and bodily, to its highest pitch of excellence. Luxury, indolence, vice, fanaticism, cant, sophistry, intrigue, and imposture, had supplanted the pure aspirations of patriotism and glory. "The great and the opulent," says Pliny and Vitruvius, "were fonder of gold and glitter than purity of design or pathos of expression, or perfection of form; overwhelmed with colours from all the countries of the earth, with double the advantages of Polygnotus, and Zeuxis, and Aristides," who painted with four only, "nulla nobilis pictura est." Of course, this is always the end, when the moral and national importance of painting is undervalued. When native art is despised, and spurious foreign productions are preferred; when connoisseurs of what *is past* abound, and connoisseurs of what *is passing* exist not; when painting is considered as a bauble or a bit of furniture, and painters share dignity with upholsterers and gilders, what wonder if "*nulla pictura*" is the cry?

Gold and vermillion being thus introduced upon the walls of palaces and preferred to beautiful art, in came arabesques. Claudius had before introduced Indian patterns and mosaic pictures, which had hitherto been kept for pavements, till Commodus, for the sake of a new sensation, had a portrait in his palace of Piscennius Niger,[1] painted in mosaic, which may be considered as the first picture of this description. When painting was in this staggering condition, Justinian gave it a final blow by ordering encaustic and distemper designs, as vulgar, to be banished from ceilings and walls, and mosaic, marble, and gold, to be preferred. Though mosaic was perhaps one of the means of preserving art and of introducing it into Italy, yet it should only be used in pavements, or to preserve the works of great masters. The anti-pagan zeal of the early Christians is well known. They used to put ropes round the necks of Apollos and Venuses to try them publicly, like criminals, find them guilty, and pound them to dust. But human nature is always the same. A thousand years afterwards a similar scene was acted in Scotland by John Knox and the reformers, nor had England escaped the fury of iconoclasm. Eusebius[2] informs us that in the empire whole towns rose and destroyed the temples in which they had just worshipped. The air echoed with the noise of hammers, the crashing of pediments, the breaking of pillars, and the shouts of a maddened and frenzied populace. The finest works of Phidias, Scopas, Polycletus, and Praxiteles, and all that was left of Polygnotus, Apelles, Zeuxis, or Euphranor, were demolished or burned, like wretches who had infected religion, and their ashes were danced on with fanatical exultation. So great indeed had been the destruction, that when Arcadius and Honorius issued a fresh edict to go on destroying, they added, as well they might, "Si qua etiam nunc in templis fanisque consistent, "If any pictures or statues are still left." During this frenzy was introduced into art, *painting without nature*, and after producing a race of monsters down to Golzius and Spranger, there began the cant of "nature putting an artist out." What Zeuxis did not dare to do, what Apelles never thought of, what Phidias never permitted to be mentioned in his school, a parcel of painters brought into practice by the very mysticism of their impossible theories. Man was corrupt, being born in sin and vicious in practice; to take him as a model therefore when painting holy subjects, was to act under the influence of Satan. Man was banished, and so was woman, and nature in every thing; till at last all painters painted in one way, and in came *manner* into the great art of nature, and like a "leperous distillment" stained her garment and poisoned her beauty. Yet the traditional maxims of the ancient fathers, on beauty and art, give one a very good idea of what were the maxims of the finer Pagan periods. "Art is nothing but an imitation of nature," says St. Athanasius, (*Orat. contr. Gent.* c. xviii. p. 18.) "Ancient artists sought to surpass each other by faithful imitation," (Arnob. *Advers. Gent.* lib. vi. fol. 68) "Nature is the archetype, art the image; every image has a model, and painters imitate what they see," (Theodoret.) "Imitation is the merit of painting; be not seduced by an illusion," (St. Clement.) "When begging the people not to be seduced by pictures and statues as if they were gods, tell them that pictures and statues are imitations of nature, and therefore cannot be gods." These maxims of the fourth century had clearly descended from a nobler era. Besides the treatises of Apelles, Euphranor, and Pamphilus, were all in existence, and were read by the educated and accomplished; and we see how skilfully the fathers of the church tried to save fine works from destruction, by assuring the people that they were *mere imitations of life*, for such was the principle of artists. Are not these quotations then collateral evidences of the practice of the Greeks, if we had known nothing of the girls of Crotona sitting to Zeuxis?

Painting.

But Christianity was at first the ruin of art, by making purity of heart every thing, and physical ugliness, or deformity, nothing; by teaching that as all beautiful works of art were remnants of idolatry, they ought to be destroyed; and by inculcating that mankind being corrupt and born in sin, no Christian painter ought to look at the naked figure whilst he was painting it. Add to these prejudices, the predilection of eastern notions for gold and silver, the preference of eastern dresses to the simplicity of Greek clothing, the controversies which took place as to whether our Saviour was ugly or handsome, and the vehemence with which Pagans and Christians both entered into them; and no one can wonder at the state into which painting declined. Influence of Christianity on the arts.

The division of opinion about the person of Christ, and the dread of the early Fathers to expose the cross to Pagans, who, familiar with golden-locked Apollos and perfumed Venuses, could not comprehend that suffering and majestic pains were founded upon a higher philosophy, so embarrassed the painters, that to avoid collision they painted Christ *as an allegory* thus lingering with their Greek feelings about the form of beauty and of grace. It must be interesting to all readers thus to trace the progress of feeling relating to the head of Christ.[3] In the fourth, fifth, and sixth centuries, beauty and youth still predominated; and he is painted youthful and handsome, crushing the lion under his feet, or as a young shepherd with his flock. With allegory the beauty of our Saviour ended, whilst the Fathers of the church, like the priests of Egypt, interfered, and issued an edict ordering him to be represented in agony on the cross. But here the order was evaded. The Greeks still struggled for the beautiful, and as if it were the never-dying principle of their souls, painted our blessed Saviour dying upon the cross, but smiling with triumphant glory as if re- Representations of Christ.

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[1] Spartian, *In Vita Pisc. Nig.* cap. 6.

[2] Montesq. *Décadence des Romains*, 133.

[3] St. Augustin declares that in his time no faces of Christ or the Virgin were known, and that no pictures were painted of them before the council of Ephesus; yet there are seven reported originals, four of which are by St. Luke's own hand, now in Rome.

Painting.

joicing in his sacrifice. In whatever the Greeks were compelled to do, beauty seemed still to be the basis of their art. By degrees, however, the poor descendants of Apelles and Polygnotus finding no employment except on the conditions prescribed, the person of Christ became gradually degraded in art; and at the separation of the Latin church, to paint him ugly, bloody and agonized, was the settled principle of representation, and has more or less influenced his representation ever since. There seems to be some doubt as to the extent of the devastation committed by the Goths. Alaric staid butthree days in Rome, and Attila had himself painted in one of his Milan palaces seated on a throne, and receiving the homage of a Roman emperor.[1] Theodoric seems to have had a very good feeling for art. He laments, in a letter to Symmachus, the ruins of works of genius, begs their preservation, and concludes with observing that Rome has still a *population* of statues with herds of bronze horses. The expulsion of the Goths and the invasion of the Lombards, again afflicted the art; but it had found its way into France, and the churches of Paris, Tours, Bordeaux and Clermont, were ornamented by native painters.

Epoch of Charlemagne.

Though the popes had begun to adorn the churches, and art in the earliest times had been kept alive with considerable talent in the catacombs in Rome; though Europe had been astonished by the splendour of the ecclesiastical patronage of painters; yet the next great epoch after Constantine originates in the efforts of the illustrious Charlemagne. He formed the plan of renovating art, science and literature; and he would have accomplished his object, if the genius of the age had been worthy of the emperor. The ancient practice of painting churches, kept alive by previous popes, he confirmed by a law; and agents every year visited the provinces to see that the law was observed. If a royal church was to be painted, the bishops and abbots were responsible. If, in the midst of a campaign, an order was issued for a church, one to paint the walls was included; and no church was considered as finished till that was done, the object of the emperor being to obliterate the remembrance of the splendid altars of the Pagans, by still more magnificent Christian ornaments. "Repair your church," says the archbishop of Treves; "you know the decision of the emperor."

Two monkish painters of the time are celebrated; and France and Britain began even at this early period, to take an interest in the arts. Biscop, abbot of Weremouth, had brought pictures from Italy. Charlemagne had invited king Offra to protect painting, with but little effect; yet though the walls of English churches were whitewashed, the English began to adorn the ceilings and the windows, and hung tapestry upon the walls.[2]

In Spain, the Arabians had introduced their art, such as it could be, under the prohibition of Mahommed; and miniatures or manuscripts were so eagerly bought all over Europe, that the artists in France, Germany and Italy, devoted themselves to this production; though here again it was acknowledged by all, that they were beaten by the Greeks. In spite of all this, the art continued to decay; and at the second Council of Nice the members gave evidence of the state to which monks and bishops had reduced it. "How can painters be blamed?" say they; "the painter *invents nothing*. Invention and composition belong to the Fathers;[3] the art alone is the painters'." Inadvertently, too, the emperor injured the art by altering the dress of his cavalry and foot. The women as usual followed the example, and having relinquished the pure taste of the Greeks, dress has in consequence become an annual novelty and change. The Paladin and his horse were covered with iron and mail; angles and straight lines predominated; the naked form was more than ever concealed, and the artist deprived of his materials.

Painting. The middle ages.

Though the art suffered at the death of Charlemagne, yet it was kept alive by monks and by bishops. At Rome, at Palermo, and at Milan, religious painters preserved it from decay; they sprung up all over Europe, and even St. Dunstan, Archbishop of Canterbury, is spoken of as a skilful painter and maker of instruments.

It is curious, after all that has been written about oil painting, and the discovery mnde by John Van Eyk, to find a writer of this period called Eraclius, in a treatise on painting, speaking of oil painting: "De omnibus coloribus cum oleo distemperatis." Another monk wrote a treatise, in which he says, "he will tell the world how the Greeks mixed their colours." Now, as according to Suidas, the writings of Apelles and Euphranor, were in existence in the tenth century, and these people lived about that time, there is reason to believe that they were aware of oil painting having been practised in ancient Greece, and that subsequent discoveries were but different revivals.

Whilst the art feebly struggled on in the west, the court of Constantine Porphyrogenitus was the rendezvous of artists, and in 997 St. Mark was built at Venice by Greeks. In contrasting Greek with Roman art at this time, the Greek is still superior. The Greek composition did not want dignity, whilst in the Roman, all sound principle seemed dead. The most ignorant Greeks shewed taste in their draperies, and their heads have character, and in the arrangement of hair, they remind one of the Panathenaic procession; whilst the Romans, with their large heads and long limbs, evince a gross ignorance of beauty.

In the tenth century, tapestry for a time superseded painting; though in Germany, France, Italy and England, many painters flourished. In England, historical commemorations were in fashion, and the Duchess of Northumberland adorned Ely Cathedral with a series of pictures illustrating the deeds of her distinguished lord.[4] When William the Conqueror came, he introduced a new style of architecture; but both at York and Canterbury, paintings then adorned the walls. In 1013, a head of Christ was executed in mosaic, and is still considered as the wonder of the middle ages.

Symptoms of revival.

After so many vicissitudes of fortune, painting now began to shew symptoms of revival. Frescos had been executed in Rome in 498, and in 795; and there was a head of Christ painted in St. John Lateran, and still to be there seen, which gave evidence of great feeling. But the grand impulse was given in the year 1066, when St. Didier sent for Greek artists to adorn Monte Casino at Subiaco. The example was followed. Pisa, Venice, Amalfi, Genoa, and Milan, all municipal corporations rivalled each other; and when Pisa sent to Greece to collect as many splendid remains of art as could be obtained to adorn the dome of the city, Buschetto, a celebrated Greek architect, was engaged to superintend their embarcation, to accompany them during the voyage, and to land them safely for the purchasers. Buschetto was received with so much enthusiasm, that he founded a school of sculpture, which existed for two hundred years; and ultimately out of this very Greek school, came the great artist Nicolo Pisano, the head of the Italico-Pisan school. From this moment art, after having sunk to the lowest barbarism, went on improving till the taking of Constantinople by Mahommed II., an event which scattered the Greeks collected at that court all over Europe. Hundreds went to Italy as painters, sculptors, chasers, and mosaic painters; and by their struggles for existence, inoculated Italian artists with some remnant of their taste for beauty, decayed as it was. Cimabue was their pupil, and Giotto was his. The Catholic church wanted artists, and genius again began to shew itself. One man of genius appeared after another, till Michel Angelo,

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[1] Suidas. [2] William of Malmsbury. [3] Concil. Nic. ii. act. vi. tom. iv. ed. 1714. [4] Strutt.

Painting. Leonardo, Raffaelle, Titian, and Corregio, were the glorious results. And though it cannot be denied that the high aspirations of Christianity, by placing every thing human on its proper level on earth, in comparison with eternal happiness, had justly prostrated the splendid beauty of Pagan art, by exposing its idolatrous tendencies; though the sufferings, and the agonies of its founder and its martyrs had revived its pathos with higher objects than mere beauty of form or face, and saved painting and sculpture from extinction; yet it must be acknowledged, that the beauty of Christian art has never rivalled the indisputable perfection of the Pagans. To their enthusiastic overestimate of the religious value of physical, as emblematic of moral beauty, is their perfection attributable; but if it can only be revived by some similar delusion, the result will in our opinion more than atone for any thing that seems doubtful or questionable in the principle.

The most eminent pictures of the middle ages, setting aside the cemeteries or catacombs, which cannot legitimately be referred to the middle ages, but to the earliest ages of Christianity, are to be found in Rome. The greatest works of the middle ages are the series of Popes, begun in the fifth century, and continued down to the present time. The next, which was executed in the year 1011, is the painting of the church of St. Urbano, where some of the Acts of the Apostles are represented on the walls. Though the mosaics of St. Mark's, executed by Greeks, were earlier, and kept art alive, yet, according to Lanzi, nothing in reality appeared which gave symptoms of the approach of any thing extraordinary, till about the thirteenth century; and this revolution of style was entirely owing to sculpture.

Italian schools of painting—The Tuscan. The glory of this art belongs partly to the Tuscans, the legitimate descendants of the ancient Etruscans, but most especially to the Pisans, who first had the courage to burst the yoke which Greek art in its fallen state had imposed upon them, and to go at once to the antique; and this glory belongs to Nicolo Pisano, a pupil of the school originally founded by the Greek Buschetto. There were in Pisa several ancient sarcophagi, but especially one, containing the body of Beatrice, mother of the Countess Matilda, with a bas-relief in good style, which served as the model of Nicolo; on this he formed his style, in which there is something of the antique, especially in his heads and draperies. Many artists who had not done so before, immediately devoted themselves to sculpture; and Nicolo Pisano must be considered as the first Italian, who opened the eyes of his contemporaries to the true principle of using the antique, that is, keeping nature in view at the moment of practice. In 1231 he cut an urn in Bologna, whence he was called "Nicolo of the urn;" and he produced two stories of the last judgment at Orvieto, and another work at Pisa, which convinced the world that he was born to found an epoch. He executed other great works, and was really the head of the illustrious school which produced Orcagna, Donatello, and the famous Lorenzo Ghiberti, who made the beautiful bronze doors of which Michel Angelo said, that they were worthy to be the gates of paradise.

Pisano. Many other eminent men came from his school. All Italy was more or less affected by Pisano's genius; and though a sculptor, his effect on design was so great, that he must be considered as having had a material influence on painting. Painting remained behind sculpture, and even mosaic; and Vasari exaggerates the effect of Cimabue's appearance in the year 1240; for Lanzi proves that there were Pisan painters of talent before that period, and that the early art does not in the first instance owe so much to the Florentines as Vasari has asserted. At Assisi there is a crucifixion by Guinta Pisano, who, according to an inscription, learned his art from the Greeks in 1210. This was before Cimabue; but Lanzi says that the work is not inferior to Cimabue, and in drapery, colour, light, and shadow, composition and expression, very like the contemporary Greeks. Guinta disappeared and died, nobody knows where or how. Guido di Sienna was another name of this early period. In the Louvre there were some exquisite heads of angels with gilt glories, full of beauty and expression, executed by this artist. Then followed Margaritone, who painted on canvass covered with size and plaster for a ground; which the Egyptians, Greeks, and Romans, had done long before his time. Painting.

During the time that the neighbouring cities had founded a new style, Florence had no painters; but when the authorities called in some Greeks in 1250, it is asserted that there was a painter called Bartolomeo. Vasari wishes of course to infer that Cimabue was the first Italian painter who gave the impulse; but Lanzi proves the contrary. Although there is no city we owe so much to as Florence, yet the Florentines ought not to be allowed to deprive their old enemies of the honour of having produced earlier painters, besides Pisano.

Cimabue. Cimabue, who was both architect and painter, was honourably descended. That he might have been the scholar of Guinta is probable, because the Italians knew more than the Greeks of that time; but there is every reason to believe that he learnt of those Greeks who had been called to Florence, and whom, according to Vasari, he stood whole days, when a boy, watching as they painted in Santa Maria Novella. From this moment indeed may be dated the excitement which impelled him to become a painter. At Assisi his genius seems to have been put forth with most power. Lanzi concludes the notice of him by saying, that Cimabue was the Michel Angelo, and Giotto the Raffaelle of his age. In the Louvre there were one or two large examples of Virgins, staring and Gothic, and which the French, still more Gothic, were absolutely repainting.[1] Vigorous in his colour, and colossal but ill-proportioned in his figures, Cimabue first gave indications of attempting something new in painting; indeed, his watching the Greeks all day is so like an infatuated youth, that it bears truth on the face of it. Florence was often in commotion when his works appeared; and although he was not actually the oldest painter, he was the first of that series which ended in Raffaelle. His style was meagre, his drapery sharp, and his colour a species of illumination; but though he had no light and shadow or perspective, he was a great man for his time; and in some of his heads there are both character and expression.

Giotto. Men of genius assist to call forth men of genius. In the neighbourhood of Florence, Cimabue accidentally found a youth tending sheep, and trying to draw one upon a slate. After some conversation with the boy, finding the youth ambitious to become an artist, he consulted his father, took him immediately under his own tuition, and advanced him rapidly. Cimabue was amply repaid for his generous conduct, as the innocent youth was Giotto, afterwards one of the great men of the time. No man can judge of Giotto's genius in England, because fragments of single heads or bits of altar pieces, are no fair criteria of a genius like his. His series of pictures in the Campo Santo are admirable, if allowance be made for the taste and simplicity of the age; but there are many actions and positions of Giotto, as fine as can be conceived, and which other artists by aggrandising in form, have rendered models of imitation. He was the friend of Dante, and painted the portrait of the great poet. He seems to have been a facetious and amiable man as well as a genius, and was indisputably the greatest painter till Massacio. He

[1] The writer of this article, who saw a Frenchman solidly repainting a large picture of Cimabue in the private rooms of the Louvre, where he was admitted by Denon, asked the Frenchman who it was by: "Monsieur," said he, "je ne suis pas peintre, je suis restaurateur."

Painting. went about Italy scattering seeds every where, and when the Papal See was moved to Avignon, he went with the court. Giotto was the greatest of the Florentine school. He was the father of painting, as Boccaccio was the father of literature. He was sought for at Ravenna, and at all the great towns of Italy, and was patronised by all the first families. He was an object of study and admiration, until the time of Raffaelle, and that of the Caraccis, and is so even at the present time. There are in Giotto instances of pathos and expression, which would do honour to any period. Thus the greater part of the merit belongs to the Florentines, but not the whole. Giotto died in 1336, when painters had increased immensely. In 1290, the first society of artists in Venice was established, under the protection of St. Luke. They were not academies, but associations of artists, composed of engravers, painters, sculptors, and orefici. Their object was to advance design in all arts; and had they always continued to act on this honest and simple principle, we should not now have had to lament in Europe a race who are synonymous with every thing weak, mannered, and absurd in art.

Buffalmaco The next distinguished artist was Buffalmaco. Although totally independent of Giotto, he was also intimate with Boccaccio. He was very capricious, and worked only when he liked, yet he was inferior to no one. He painted the Crucifixion, Resurrection, Ascension, and Creation of the World in the Campo Santo; in fact, the Campo Santo seems to have been a receptacle for all the distinguished geniuses as they appeared in that age. In it there are things as fine in conception as were ever imagined; and the foundation of some of Raffaelle's best compositions in the Vatican may be there found. Vasari's life of Buffalmaco is exceedingly entertaining, as indeed all his lives are.

The Orcagnas. The two Orcagnas, Andrea and Bernardo, were the next artists of this early school. Andrea, painted the Judgment and the Inferno, in the Campo Santo. He was full of invention, but not equal to the Giotto school, though he first gave evidence of perspective. Lanzi thinks that the art did not advance so quickly after Giotto's death as it ought to have done. Taddeo Gaddi, his best pupil, was to him what Julio Romano was to Raffaelle. Vasari, who saw his pictures in good condition, says, that he excelled his master in fleshiness and colour. Agnolo Gaddi the son of Taddeo, was a humble imitator of Giotto and his father, and had as his pupil Cennino Cennini, whose treatise on the mechanical preparations of the art is very valuable. Fortunate would it have been had the treatises of Apelles and Euphranor also reached us.

Florentine school. Pisa now began to decline, and the Florentines took possession of that city in 1406. Hated and detested by their conquerors, the spirit of the citizens sunk into the greatest depression; the artists left the city, and the school entirely decayed. The Florentines now rose in the ascendant. The Medici began to appear. Cosimo, the father of his country and the protector of genius, gave fresh energy to art, science, and public affairs. Lorenzo followed, and their house became the refuge and resort of all who were celebrated in painting, poetry, sculpture, architecture, and philosophy. Masaccio, the two Piselli, the two Lippi, Binozzo, Sandro, and Ghirlandaio, received from the Medici protection and employment. The pictures of the time have perpetual portraits of the Medici. The citizens became animated with the same spirit; frescoes covered the churches, and smaller works filled the houses. Up sprung, too, that host of painters, marble-cutters, bronze-casters, and chasers, by which the principles of design passed from Pisa to Florence; and out blazed before the world Donatello, Brunelleschi, Ghiberti. The most exquisite productions of sculpture, marble, and bronze followed. The youth became inoculated; sound design became the first necessity of manufacture; and though the finest works of Italy at this or any period cannot be compared to the finest works of Greece, yet a good style of design was established, but unequal to those refined forms of beauty, so palpable in the merest fragments of the works of the school of Phidias, which have all the look of life without any of its vulgarities, all the essential details, without a single superfluous one. This cannot be said of the naked figures of the period in question, or of any period of Italian art, not even of the art of Michel Angelo and Raffaelle. There was a want which Greek forms only supplied; there was an absence of refinement, and a want of something which the Greeks possessed. Michel Angelo and Raffaelle were educated without system. There was no school in Italy like the schools of Sicyon and Rhodes, Athens, and Corinth, where all the hidden secrets of perfect form were taught, that is, the secret of beauty. Michel Angelo and Raffaelle owed their greatness to their own genius; and their art died with them. There has been nothing in the world like the art of Phidias, except the poetry of Shakespeare. The intellectual powers and perceptive senses of the Greeks must have been several degrees more refined than those of all preceding or subsequent nations.

Painting.

Massaccio The followers of Giotto had advanced the art from infancy in colour, composition, and expression; but in perspective, and light and shadow, they left it as they found it. Uccello had given symptoms of perspective, and Massolino da Panicale of light and shadow, until the appearance of Masso di S. Giovanni, a youth so immersed in study, so utterly absorbed in his divine art, that he neglected dress, health, food, sleep, and seemed only to be conscious of life when he touched a pencil. For this entire neglect of the humanities and comforts of life, the Italians, whose satirical turn is ever apparent, added *accio* to Masso, (*accio* affixed to any word exciting associations of dirt or ugliness,) so that Mass*accio* meant a dirty and neglectful man. Neglectful as he was, however, he was the immediate precursor of Raffaelle; and all the great subsequent painters studied him. Raffaelle borrowed from him Paul in Elymas, the Adam and the Eve in the Loggia, and other entire figures. Like Apollodorus, he opened the doors; and Raffaelle having passed through, never forgot his obligations. Ghiberti and Donatello formed his style; from Brunaleschi he learnt proportion; and though the finest antiques were not known in his time, he improved himself by studying such as were in existence. The airs of his heads are *Raffaellesque*, says Mengs; yet, would it not be more just to say, that Raffaelle's heads are *Massaciesque?* Raffaelle died the favourite of a court, loved, lamented, and in competence. Massaccio so excited the envy of his inferiors, that it is suspected he was poisoned at the age of twenty-eight, before he had fairly taken his ground. Surely, then, when Massaccio is praised for what must have been his own, it is not quite fair to term his excellence, that of a man who came after him, and perhaps owed it to him. His works are at S. Ambrogio, and del Carmine in Florence, and St. Catherine in Rome. His heads are full of character, his drapery is beautifully composed, and his composition is unaffected, but his knowledge of the naked form is feeble and vulgar. Some of the heads of del Carmine are full of character like Holbein, with the same look of rigidity in expression; but he was a true genius, benefiting by his predecessors, going beyond them, and enabling those who studied him to carry the art to the highest point it ever reached in Italy. Pietro Perrugino, Leonardo, Raffaelle, and Michel Angelo, all studied and all were benefited by him. In the Palazzo Pitti there is a portrait of a young man who looks alive.

Ghirlandaio After several names of great merit, we reach one who advanced towards the great era; we mean Domenicho Ghirlandaio, the master of Michel Angelo, a circumstance which alone is a passport to immortality. Fuseli says, that he was the first Florentine who added truth to composition by truth of perspective. The abolition of gold fringes in drapery may

Painting. be dated from him; though his historical figures are little more than portraits well-selected. The last important name of the first epoch of Italian art was that of Luca Signorelli, who had glimpses of real grandeur. His dome at Orvieto, where he painted the Last Judgment, has bold fore-shortening, with absurdities of an earlier date mixed up in it; but Michel Angelo adopted many of his ideas, as well as Dante's; and certainly the absurd assertion that he "disdained to look abroad for foreign help,"[1] is successfully refuted by this fact.

One can see how gradually art sunk after its decay into Gothicism; how gradually it advanced again to nature and common sense, and from common sense to elevation. During this first period the approaches to ideal beauty, imperfect as it was in Italian art, were gradual, and would have been longer in coming had not the discovery of the Apollo, and other ancient works, opened the eyes of all the great men living, and a spring taken place from Perrugino, Ghirlandaio, and the Bellinis, which was soon visible in the works of Raffaelle and Michel Angelo. Leonardo seems not to have been smitten by the ancients to the same degree as the other two were. There is less obligation to any nation in him; and unquestionably few as are left of the effusions of his genius, they are more original than the Vatican or Sistine Chapel. What was there in the world to put us in mind of the Standard struggle or Last Supper of Da Vinci?

Oil painting. But before proceeding, it may be as well to allude to the question of oil painting. It was long a supposition that Van Eyk discovered it, and that it was not known before; whereas, it was used in England in 1230, long before the time of Van Eyk. Cennino Cennini wrote a treatise on the technical practice of the Italian painters; he was a pupil of Agnolo Gaddi, who was a pupil of Taddeo Gaddi, who was a pupil of Giotto, who was a pupil of Cimabue, who was a pupil of the Greeks. There can be no question that from the mixture of oil with punic wax[2] as a varnish, the use of oil was known to the ancient Greeks, and that it was carried on to the tenth century, when the monk Theophilus[3] wrote his treatise. He positively describes how to mix the colour with oil instead of water, and how to boil the oil; and then we can prove its existence by actual documents in the rolls of the Exchequer in England (1239), and by the 23d of Henry III., wherein the king issues an order to "our treasurer Odo the goldsmith and his son, to be paid 117 shillings for *oil*, *varnish*, and *colors* bought, and for pictures made in the chamber of our Queen at Westminster,"[4] nearly two hundred years before Van Eyk. There can be no doubt that oil painting has never been unknown, even to the Egyptians; it has been forgotten and revived, but none of the periods of revivals are entitled to the honour of discovery. "Chaque nation a ses avantages, et ses désavantages," said a Frenchman to us, whilst shrugging his shoulders as a spout of water from a roof drenched him to the skin in Paris; and "Ogni nazione ha le sue virtù, ha i suoi vizi," says Lanzi. Every nation which confesses its vices, is sure to have justice done to its virtues. There is no Italian school, however good, which has not its errors, and none which has not its excellencies as well as its mistakes.

Florence was distinguished for fresco more than for oil painting. The Florentine style of design, in its best days, was always peculiar; the figures were long in proportion, their feet were small, and so were their knees; there was always a look, in Florentine design, as if the muscles of the body were suffering from a temporary knotted cramp; they were, in design, too circular, too elliptical, or too angular, and never seemed to have hit the exact medium between all three, like Phidias. Their colour was not rich, like the Venetians; their draperies clung too closely to the limb as if they were wet; they made an ostentatious display of the limb underneath; in fact their system degenerated into manner, and beauty seems not to have been a primary object in the Florentine school, any more than in that of their ancestors the Etruscans. At Fontainebleau, though the designs of Primaticcio were full of talent, yet they gave a very good idea of the excess of the Florentine manner.[5] The two great luminaries of Florence were Da Vinci and Michel Angelo. Da Vinci was less of a mannerist than the other great man. He was, in fact, the link between the meagreness of the first period of design, and the vulgar swing of the second. Painting.

Leonardo was born in 1452. He was a natural son, and had all the eccentricity, sloth and fire, weakness and energy, idleness and diligence of that class. A poet, a musician, a mathematician, an hydraulist, a mechanic, a modeller, and a painter; he excelled in all. Keen, eager, minute, searching and indefatigable, handsome in face, beautiful in person, tall in figure, athletic and skilled in manly exercises, a graceful dancer, a splendid horseman, and an harmonious singer; he equally delighted the people, infatuated the women, and bewitched the sovereign. And yet with all this vast power, the gift of his Creator, he was so deficient in concentration of mind, that he seemed to have no power of collecting its rays sufficiently long to make discoveries in any thing. He was the scholar of Verocchio, by whom he was infected with a lazy love of design in preference to the vigorous energy of using the brush. He passionately loved geometry, horses, and soldiers; and in his horses he never left nature like Raffaelle, Julio Romano, or Michel Angelo, but gave them their natural characteristics of fleshy nostrils and projecting eyes. Leonardi da Vinci.

His two greatest works are his Last Supper, and his Battle of the Standard. The beautiful humility of Christ, the tender amiability of St. John, the powerful expressions of all the apostles waving to and fro in their attitudes, as if disturbed in their feelings, by the remark of Christ, that "one of them should betray him," prove the extent of his genius, and the depth of his perceptions. But even here, the bane of his existence, that disposition to experiment, has ruined the work, more from the consequences of his own preparations, than either time or damp. Such men are never regarded as steady lights by posterity; painting was only a portion of his occupations, and not the end of his life. One quarter of the lives of such men is spent in experiments; another quarter in putting them in practice; a third in lamenting their failure; and the last amidst the bitterest remorse, devoting themselves to their real pursuit, to satisfy the cravings of conscience and the reproach of the world. What has Leonardo left us in all his various pursuits to compensate us for the loss which accrued to painting? Geometry was as much a caprice of his extraordinary mind, as any other science. What has he left us in poetry, which poets could look up to? What in mechanics, that Watt could have founded on? What in music, that would have benefitted Mozart? What in hydraulics, that would improve our shares in canals? The genius that composed such works as the Standard and Last Supper, need not to have shrunk from competition with Michel Angelo, young as he was. There is no doubt the world is always delighted to pull down an established artist by pushing up a younger rival in his face; but if you become irritable, and desert your

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[1] Reynold's note.

[2] Pliny, lib. xxxv. Cera punica cum oleo liquefacta.

[3] Lib. i. c. 18. Accipe semen lini et exsicca illud in sartagine super ignem sine aqua, &c. Again, "cum *hoc oleo* tere minium, *super lapidem*;" and again, "accipe colores quos impone volvens, *texens eos* diligenter cum *oleo lini*." *(De omni Scientia Artis Pingendi.)*

[4] Rot. Claus. 23d Henry III. Walpole's *Works*, vol. iii. p. 16.

[5] In 1814, the writer saw the remains. There was a naked youth over one of the gateways, which had all the peculiarities of this school.

Painting. country from disgust, men only laugh; whereas the sound principle is, Laugh at the world, stay in your country, and work harder than ever.

The fact is, that such men as Leonardo are great geniuses, but not the greatest. The evidence of superior genius is the power of intellectual concentration. Such powers had Newton, Milton, Bacou, Locke, Watt, Michel Angelo, Napoleon, Raffaelle, Titian, Rubens, Vandyke, and our own Reynolds. Such men only are examples, and not beacons; such men only are blessings to their species. As a specimen of his extraordinary caprice of character, his want of perseverance, and his notions of the most elaborate finish were at least equal; he took four years in painting one face, and then said it was not done. His children are exquisite; but his women have an air of modesty to conceal meritriciousness, and his oil-works are far from models of excellence, the over-wrought finish being hard. There is always in his expressions an air as if they were set in enamel, and could not relax. The picture, in our national gallery, of Christ and the Doctors, is a celebrated work; but why should Christ, who disputed with the doctors at twelve years of age, be larger in person and head than the doctors who are sixty? And why should Christ be like a woman in men's clothes, and look out of the picture, and talk with his fingers to the spectators, instead of being, as he was, a fine boy of twelve years old, handsome, intellectual and angelic? We should like to have heard Leonardo's reasons, if he had any, for such an apparent absurdity.

In design, and tempera or fresco-painting, Da Vinci was great; but in oil pictures he is false in taste, petty in execution, and unskilful in backgrounds. By his depth of light and shade, and also of colour, which gave an impulse to all Italian art, he had a sense of beauty which greater steadiness might have brought out to perfection. But when a man flies off from painting to make a lion, which will walk by machinery, to meet the king of France who approached Milan, to stand upon his hind legs without human help, to open his own belly, and show the king of France his arms inside it, what could be expected from his talents, great as they were? Nowhere does his character show itself more conspicuously than in his treatise on painting; in fact it is not a treatise, but a collection of separate disjointed thoughts, like the recipes of a cookery book. It is very easy to put down your thoughts as they occur without arrangement; but the difficulty is, to collect them for the illustration of a principle like Fuseli or Reynolds. Every man can put down separate thoughts, but every man has not the power so to arrange them as to throw light upon an art. Leonardo dissected and drew finely; but there was a meagre common-model style in his figures, a want of perfect construction, as if men had never worn clothes. On the whole, this illustrious man cannot be referred to as the head of an epoch. He was a component part of it, but not like Michel Angelo or Raffaelle the great engineer. What he did in painting made one lament that he had not done more. "An artist," says Reynolds in his letter to Barry, "should bring his mind to bear on painting, from the moment he rises till he goes to bed; and if his mind be calm and undisturbed by other objects, he will find it quite enough to fill up life, if it was longer than it is."

Michel Angelo. No man could be more opposite to Leonardo, than his great successor Michel Angelo, patient, laborious, virtuous and indefatigable, painter, architect and sculptor; he left a work in each art that advanced the rank of his country. To turn to such a character, is a relief and a blessing. In him the aspiring youth contemplates the result of conduct totally the reverse of that we have been considering. Solitary, and highly gifted, despising the subterfuges of society, he lived alone; and in addition to his genius he was a great moral being. Brought up by the liberality of Lorenzo dè Medici, admitted freely at his table with the illustrious men of the day, Michel Angelo had every advantage in early education. He came, too, when he was wanted; when ancient literature and ancient art were breaking through the obscurity which had overwhelmed them, and the discovery of printing was scattering their beauties throughout Europe. Men's minds were roused up with wonder and delight at every fresh discovery. Painting, architecture, poetry, and science were hailed with a gusto which nothing can account for but the misery of the ages that had passed. Painting.

Michel Angelo, after his day's study in the gardens which Lorenzo had opened for the youth of Florence, retired to the coins, cameos, and fragments of the palace. With his acuteness, energy, and perception, it is not wonderful that he soon perceived the inferiority of the forms of his master, in comparison with the full beauty of the form, the result of perfect construction in the antique. He corrected with his boyish hand the narrow meagreness of Ghirlandaio; and announced, thus early, that self-will and vigorous decision, which enabled him subsequently to accomplish whatever he undertook. Here was the germ of that mighty power which placed the Pantheon in the air, as he predicted and realized in the dome of St. Peter's. Here was the embryo fearlessness, that brought him through the vast ceiling of the Sistine Chapel in fresco, though when he began it, he had never painted in fresco before. Michel Angelo was one of those rare beings who are wanted when they come, and have opportunities put in their way adequate to develope the powers with which they are gifted. Julius II. was as wonderful a man as Michel Angelo; and they mutually inspired each other. What Julius willed, Michel Angelo was as ready to perform; and what the inspirations of Michel Angelo's genius suggested, the vigorous pope, whose fine old venerable head a helmet would have suited better than a tiara, had comprehension to value. They were both fierce, both self-willed, both proud and haughty, both independent and ungovernable. If Julius wished what Michel Angelo was in no humour to do, he would not do it; and if Michel Angelo wanted to execute, on sound principles of art, what the aged pontiff did not comprehend, he would do it, in spite of denunciations of banishment, or threats of displeasure. They were made for each other, they understood each other, and they were attached to each other; they quarrelled, became friends, and quarrelled again. "When will the ceiling be finished?" said Julius, as he trod on the scaffolding with a stamp that made the boards tremble, after climbing to the top, where the great artist lay on his back on a mattress, hard at work, painting with vigour. "When I can," said Michel Angelo, irritated at the interruption. "When thou canst," thundered out the pope; "Art thou minded to be hanged?"

This was the man for Michel Angelo. Conscious of his age, conscious that death followed him wherever he went, he began, proceeded with, and finished all he undertook, as if he had not an hour to live. By his perpetual watching, he hurried Michel Angelo through the ceiling of the chapel in twenty months, a time by no means equal to that which ought to have been devoted to it. The hurry is visible in the fierce, rapid execution; and that which was entirely owing to the impetuosity of his old patron, has been attributed as a merit and a principle to the great painter. Such is the infatuation of praise when a man is really great. Of this astonishing work, it seems that enough can never be said; though language has been exhausted to do it justice. Fuseli was the first who cleared up the mystery of the composition, in a style that places the commentator on a level with the inventor. "It exhibits," he says, "the origin, the progress, and the final dispensation of theocracy." But Fuseli's character of Michel Angelo is overdone. It is an effort to express the deepest feelings in the strongest language; and in all such efforts the language invariably becomes inflated and turgid.

Painting. In comparing this illustrious sovereign of modern design with Phidias, or the Greeks generally in the naked figure, he must unquestionably yield to them the palm. Michel Angelo often perplexed his limbs with useless anatomy; it must not be denied, and cannot be refuted, that he did not always clear the accidental from the superfluous. If the principle be a sound one, namely, "that any two parts of a body bearing comparison must keep a consistency throughout, similar in essence and similar in development," then is Michel Angelo grossly inconsistent; because if the spine of the ilium in front be covered fully by the muscles around it, so ought the spine of the scapula behind to be equally covered. If the former be, and the latter be not, then the figure is inharmonious and inconsistent, and what Phidias would never have tolerated. Now the figure of Michel Angelo's Christ standing with a cross, has the spine of the scapula prominent and bony, and all the muscles shrinking from it, the characteristics of a thin man; whilst the spine of the ilium of the same figure in front, is entirely covered by the muscles around it, the marks of a muscular and fleshy man. What authority had Michel Angelo in nature or antiquity for such inconsistency? These are the excesses which bring dissection into contempt, and which induce anatomists to doubt whether the Greeks dissected or not, because they were never guilty of such absurdities, and because they had too much self-control to make that an end of art which was but a means of the perfection of art. And yet Vasari calls it "mirabilissima." This figure and the Lazarus in Piombo's, as well as several figures in the Last Judgment, are justifiable grounds for asserting he was not equal to the Greeks in the naked figure; though in the conception and arrangement of a vast whole to illustrate a grand principle, he approaches but does not surpass the Parthenon in its glories. In the form he must not be compared to the Greeks; gigantic as he is, he was decidedly inferior.

Michel Angelo's line is by no means "uniformly grand;" and his women may be "moulds of generation," but certainly not of love. His infants may "teem with the man," but they have nothing of the infant. His men may be a "race of giants," but they are brutal in expression, fierce in action, and distorted in position. It is useless in a rapid and general view of art to go over ground which has been so often gone over before; to talk about the prophets and sibyls, after three hundred years' enthusiasm, is worse than useless. Europe knows the awful grandeur of one or two of them, looking like beings to whom God has spoken, and who have never since ceased meditating on the awful voice.

The style of Michel Angelo has been called the style of the gods; but if majesty without pretension, humility without feebleness, power without exertion, and an awful presence without vulgar assumption, be the characteristics of a god, what figure of Michel Angelo's deserves that appellation? Is it in the bullying defiance of Moses? the twisted tortures of Jonah? the cramped agonies of the sleeping Adam? or the galvanized violence of the ornamental figures at the tombs? It must be admitted, that the *Pensoso-Duca* is majestic and silent; but this is an exception, not an habitual characteristic. "Michel Angelo's mind," says Reynolds, "was so original that he disdained to look abroad for foreign help." Disdained! Why there is not a prophet, a sibyl, or a naked figure in the whole chapel where the torso cannot be traced. And what are the works of both Michel Angelo and Raffaelle, but improved completions of all that their predecessors had done for a thousand years in barbarism and obscurity? Shakespeare's plots are all borrowed; Lady Macbeth is not his own; that hideous expression "know Macduff was from his mother's womb untimely ripped," is Hollingshed's. But what of that? It is the new thoughts he puts into them, which give him claim to the sympathy of the world. Phidias and Raffaelle have one great and decided beauty in their works; their figures, whether in action or expression, always look as the unconscious agents of an impulsion they cannot help. You are never drawn aside from what they are doing by any appearance in them, as if they wished to make you consider how very grand they were, or how very gracefully they were moving. They seem impelled by something they cannot controul; their heads, hands, feet, and bodies immediately put themselves into positions the best adapted to execute the intentions wanted; whereas *often* in Michel Angelo, and *always* in his imitators, there is a consciousness as it were in his arms and limbs, which destroys all idea, as if his figures were the unconscious agents of an impulsion they could not help, and which acted by means of the will on the muscular system. Painting.

It is an inherent principle of life never to disturb itself for grace, or for any other object either in action or repose, not immediately the natural consequence of the impulsion which moved the body. Style in design is a *result* and not a *cause*. Whatever object is represented in painting or sculpture, the intentions of God in its bodily formation should be ascertained; the means which God has bestowed on it to enable it to execute its only will or gratify its own instincts, should be investigated; and then the aberrations produced by time, accident or disease, or other causes, will be clearly known, so that he who takes upon himself to represent any object in painting, will be able to distinguish accident from essence, and shew the object in its essential properties of body as God first created it. The external form in that body will then be *essential*, and the result of its completion in art will be *style* in design. There are certain inherent principles of our common nature to which all bodies must yield, viz. that compression and extension must have different effects, and so must repose and action. If a great artist represents a figure and makes its parts the same in either case, he must be ignorant of nature or above its simplicity. No doubt, the conception of an idea may be so grand, the beauty of a character may be so angelic, the pathos of an expression may be so deep, that errors or inadequacy in the mode of representation may be overlooked or forgiven; but in order to bring the art to the perfection to which the Greeks brought it, there must be nothing to forgive or to overlook. An idea or conception being the nobler part of the art, we may, in our common conviction of human frailty, *overlook* any inadequacy in the means of imitation; but the very admission proves there must be something to be overlooked and something which, we have a notion, has not been adequately represented.

An art the modes of which to convey thoughts, being the imitation essentially of natural objects, ought surely to have the imitation perfect, because the imperfection of the means has always detracted from the impressions of the thought. Poets are not endured if their grammar is bad, or their language defective; and why should drawing, form, colour, or light, shadow, and surface, the grammar of art, be excused more than the poets'? Because the simplest imitation is at once recognised as the imitation of the prototype, why should facility of imitation be any excuse for defect? Ah, but its the *grand* style. Yes, the grand style of Europe for the last three hundred years; but was it the grand style of the Greeks? Certainly not; their grand style was nature elevated not violated, with none of her inherent bases of life altered a hair's point, none of her essential details omitted, and none of her essential principles overwhelmed by useless detail.

When you see an outline like iron, that is the grand style. When hands were twisted, heads distorted, one leg up, and the other so far removed from the body, that you may question if it will return, that is the *grand style*. All this absurdity originated with Michel Angelo; and though he is not answerable for the excesses of his admirers, there must be

Painting. something erroneous if every imitator has led to such extravagance from Goltzius downwards. Michel Angelo was a tremendous genius, and his effect on the art was vital; but he did not like the Greeks suffer the unalterable principles of life to keep in check his anatomical knowledge. This was an error, because we can imagine no beings, and no world where malleable matter is not influenced by the common principles of the solar system, or where any creatures composed of bones, muscles, tendons, and skin, must not yield to the laws which God instituted for their government when he created them.

Thus Michel Angelo often overstepped the modesty of truth, and gave a swaggering air to his figures. Every figure of his looks as if he was insulted and preparing to return a blow. If they sleep they seem as if they would kick; if they move when they are awake, they seem as if all their muscles were cracking. We allude particularly to the naked figures; Jeremiah and the Duke are exceptions, but they are only exceptions. Fuseli observed that Michel Angelo was the *salt of art;* but it would have been more just to have called him the *pepper*, because very little indeed will do for a seasoning. In poetry of sentiment the Medici tombs would perhaps have competed with Phidias; for Michel Angelo being a painter as well as Phidias, he combined in his sculpture a knowledge of effect. In selection of subject and daring execution of hand, perhaps the Sistine Chapel might equal the great works of painting amongst the ancients; but in naked representations *it cannot be compared to it.* The Elgin marbles had not then enlightened the world. The due subordination of all science to nature had not then been so exquisitely seen; the due combination of life without meanness, and of abstraction without losing sight of life, were not so apparent in the great works of ancient art which were found before this period. Had Michel Angelo seen the Theseus and Ilyssus, Jupiter's breast and horse's head, he would have felt the difference between the muscular swing of a blacksmith, and a hero naturally born powerful, without his muscles being distorted by manual labour; and that a hero might be elevated and yet simple, fleshy without fatness, and muscular without being skinny. Michel Angelo has been called the Deity of design; but he was rather the Devil. One can imagine the consternation of Phidias and his pupils, if suddenly at Olympia the galvanized figures of the tombs had been let down through the roof, whilst they were preparing the Olympian Jupiter, with his quiet, solemn, steady, thinking, peaceful, awful look.

Reynolds says he prepared the way for the sweeping outline of Rubens; but how many thousands has he ruined? What is the excellence of the Last Judgment? Is there any evidence of power in arranging a whole, like Rubens, Titian, or Tintoretto? Is there any application of any principle of our nature by the due combination of variety and repose? Is it not a mass of separate groups, vulgar in design, academic in action, and demoniac in expression? Is the Christ worthy of Goltzius? Surely it would have disgraced him, and then what devils! Are these the fallen angels of heaven? they are the legitimate offspring of hell. Are these the beings whose glory was obscured, not extinguished? whose majestic forms existed, though in ruin? whose beauty was only disturbed by passions, not destroyed? who were the same grand, heroic, terrific beings as ever, but scathed by lightning, singed by fire, dingy from darkness, lacerated by thunder, their splendour sparkling through the horrid obscurity, in which they meditated revenge? To give them mouths like wolves, ears like asses, noses like pug-dogs, and tails like monkeys, with feet cloven and misshapen, was not to represent a fallen angel, but a deformed monster. Though evil, they were beautiful.

> "—— Their forms had not yet lost
> *All* their original brightness."

"What matter where, if still I be the same?" says Satan. Could such a sentiment have ever been uttered by the wretch who is dragging a figure down to the bottomless pit, in a way delicacy forbids one even to think of, much more to write or to paint? Michel Angelo's demons would not only torture the damned, but feed upon their bodies. Painting.

It is clear, however, that there *was* a time when he was not so exaggerated. The holy Family, in sculpture, brought by Sir George Beaumont from Italy, is playful, natural, simple, and beautiful; it is in fact a divine work. Perhaps the violence of Julius in hurrying him through the Sistine Chapel, and the necessity of painting with tremendous exaggeration, on so large a space, got his hand into a fierce power that it never lost. Painting on grand ceilings is like talking in large theatres. He never entirely finished any thing; he left no grand pupils, like Raffaelle; he assisted the humble, but never instructed the gifted. The figure of Lazarus in our national picture, especially the hand and thumb that press the shoulder of the attendant on the left side, is certainly by him; and if it be compared to the timid painting of the Christ, the spectator will be convinced of it. In fine, Michel Angelo was a great genius; but let the students of Europe be assured that his style has been grossly overrated; let them banish his works from their eyes, and substitute the Theseus and Ilyssus, and the real grand natural style of Phidias will soon exclude the satanic Etruscan, and violent anatomical distortions of Michel Angelo. He may be and was a giant in art; but Raffaelle was an angel, and Phidias a god.

The next Florentine of power was the monk Bartolomeo. Bartolemeo
He studied under Rosselli, and Leonardo aroused and excited him; he was grand in colour, light and shadow, and execution, surface, and character. In the Louvre there were works worthy of any hand, any competitor, or any genius. He had the honour of advancing Raffaelle; he invented the lay figure, and made the proper use of it; he never put drapery on it till he had drawn the naked figure first, so that the naked parts affected the forms of his folds; he had great depth, grandeur, and a certain wildness of air; he drew finely, and his tones were solemn and elevated. Wilkie speaks with the highest enthusiasm of his Assumption of the Virgin. It is impossible not to feel the deepest interest in Bartolomeo, and not to be astonished that he did not found a school, and head an epoch. Such things, however, are never done by the mere influence of talent; the character of the man is principally though not wholly the cause. He painted a S. Sebastiano, which was so beautiful, that it became a favourite of Italian ladies. He was ordered to adorn the great hall of council at Florence, as Da Vinci and Michel Angelo had done before; but as if a fatality attended that hall, he died without going further than the designs. This is curious. Da Vinci designed the Standard struggle; Michel Angelo the group of soldiers alarmed by the trumpet, and dressing themselves; and now Bartolomeo began his designs, and died in 1517, without completing them. Bartolomeo was a great artist. His method was first to draw the naked figure, then clothe it, then paint the whole picture in light and shade in oil, and then tone and colour, guided by the tremendous depth of his first impasto painting.

Andrea Del Sarto is another name enthusiastically over- Andrea del
rated by Vasari. He might be called Andrea senza errori; Sarto.
but what genius "senza errori," ever enchanted the world? Give us the vigour of Michel Angelo, with all his violence, the dash of Tintoretto with all his caprice, the colour of Titian with his want of drawing at first, the sweetness of Corregio with his namby-pamby men. the composition of Rubens with his flabby women, the expression of Raffaelle with his hardness of effect; but spare us from that poet, painter, musician, or moral character, who is so perfect that he must be admired without the gusto of finding fault; above all, spare us from the Grandisons of art. Andrea was

Painting. one of those to whom talent is more applicable than genius; whatever excellence he attained, he would have never attained to that degree, but for the existence of his superiors. The greater part of the works attributed to him in England, are copies by his pupils which he retouched.

Decline of the Florentine school. After these great men, it would be useless to detail the decay of the Florentine school; it yielded to the circumstances of the time, and the misfortunes of the Medici. The continual political squabbles turned men's minds from art as in ancient Greece; but the great want of course was the want of genius, which no efforts have since been able to rear. Though the style of the Florentine school was not so pure as that of the Roman, it led the way in a noble manner, and kept side by side with it; they benefitted each other. Leonardo gave an impulse to art; and though from the caprice of his character, he did not complete the impulse he had given, and was more the cause of greatness in others, than the man who established his own, yet the art is indebted to this highly-gifted man, who had an effect on Georgione, Bartolomeo, Raffaelle, and Michel Angelo himself; and gratitude is due to his genius. This great school was brought to utter ruin by what Lanzi calls the Cortoneschi, or pupils of Cortona, where art had degenerated into mechanism, and thoughtless, endless, and sprawling groups. The descendants of the Medici breed had more disposition than power to patronise, till Leopold reigned in 1765. The academy was renovated in 1785, and once more in 1804; but these renovations end in nothing. The great men were passed without these conventional distinctions; the little ones who came after, live only by their embellishment. Boys are educated to draw tolerably well, to colour with tolerable harmony, to invent tolerably insipidly, to become intolerable painters, accomplished academicians, to die, be buried, and decay; and thus leave room for another race as intolerably imbecile in art, as their illustrious performers before them. It is quite absurd to read in Lanzi, always at the end of the epochs of a school, "Decadenza dell' arte, e *fondazione dell' academia per avivvarla*;" "decay of art, and foundation of an academy, to give it life." But after a few galvanic twitches it stretches out its feeble legs, gasps with an expiring quickness, gives a trembling of its eyelids, which it opens once more, stares with a fixed look, sighs deeply, and drops its jaw for ever. Then come the vain efforts to restore circulation, then the delusive assurances that it is still living; then doctors and nurses dress up its helpless head with laurel, and put some abracadabra on its cold breast; but all won't do for it's gone and there is no hope. Such have been the results of the academies. Genius fled at their foundation, and left them useless bodies without soul, life, or circulation. The sovereigns of Europe will at last find out that no academies should go further than schools; and till they do, the end of art will be forgotten, in a vain contemptible struggle for its conventional distinctions.

Roman School. The three leading lights of art as schools, are the Florentine, the Roman, and the Venetian. The Parman must in spite of all the beauty of Corregio, be considered as the beginning of corruption. The other schools, the Modenese, the Cremonese, the Ferarrese, Genoese, and the Piedmontese, are but different branches.

Raffaelle. The glory of Italian art is Raffaelle. Had he been born in Greece, and qualified by a Greek education, he would have been as great in painting as Phidias was in sculpture; but the education of all the Italian artists was imperfect, and they seemed to be grounding themselves, (even Raffaelle himself,) on the meagre style of the early painters. The discovery of ancient statues in some degree opened their eyes, but they were not, like the ancients, gradually prepared for such perfection, nor was Raffaelle himself ever skilled in those perfect principles of beauty, as applied to the naked figure, which distinguished the Greeks. Wonderful, amiable, and gentle creature as he was, the reverse of Michel Angelo in every way, who proved himself decidedly the inferior man. In all his endless inventions, a single repetition of himself, even in the folds of a drapery, is not to be found; he was not like Titian, an exquisite colourist, but his colour is always agreeable, though not distinguished for light and shade; and his groups are never obtrusive, though not remarkable for aërial perspective. Every object keeps its place; though no face of his can compete with the beauty of the ancients, his women always enchant; his great power was character and expression, and telling a story by human passions and actions; in these he was unrivalled in modern art, and not surpassed by the ancients. His father being a painter, he was bred up in the art; and his master Perrugino, was a great man in his way, though somewhat of a Goth. In style, therefore, Raffaelle lost time with him; but could he have gone in early life to such a school as Sicyon, there is no knowing to what a pitch of perfection he might have carried the art. His latter excellence is entirely owing to his own sense, based on the antique; for most of what he learnt from Perrugino he had afterwards to unlearn. He entered the Vatican at twenty-five, and died at thirty-seven. What then must have been his diligence, his devotion, and his genius. In any history of painting, at this time of day, to talk of the subjects of the Vatican, or the Madonnas, so often copied, so often engraved, so often seen, so often praised, would be trespassing on the temper of the reader. His character, as well as that of his art, was the very converse of Michel Angelo. Michel Angelo envied his equals, was kind to his inferiors, and always insulting to his superiors; whilst Raffaelle was kind to all, and the idol of the society in which he moved. Michel Angelo associated with no men but admirers. The consequence was that his life was written by his flatterers Condivi and Vasari, a great portion, perhaps, delicately insinuated by himself; and, as might be expected, they have sacrificed Raffaelle to the Dagon of their idolatry. Vasari insinuated that Raffaelle was greatly indebted to Michel Angelo; and Reynolds following Vasari and Condivi, goes farther than either, asserting that Raffaelle owed his *existence* to Michel Angelo. Was there ever such gratuitous assumption? If it means any thing, it means that but for Michel Angelo, his genius would never have been developed. Is such an absurdity worthy of Reynold's understanding? Surely not, and in fact it can be made clear that Raffaelle did not owe his existence to Michel Angelo. If he owed any thing to that great artist, he owed the corruption of his own pure style. After the Capella Sistina was opened, Raffaelle, bit like every body else by its heavy, cumbrous, vulgar, broad, and circular design, immediately tried it; but it did not suit his beautiful nature any more than it would have suited the elliptical beauty of the heroic forms of Greece.

What does Reynolds mean when he says, that "Raffaelle had more taste and fancy, Michel Angelo more genius and imagination?" If genius be nothing more than the ordinary faculties of men carried to a greater pitch of intensity than ordinary men possess them, wherein had Michel Angelo more genius than Raffaelle? Their geniuses were both equal; but the road which each took for the exercise of his genius was different. Raffaelle excelled in expressing the passions; Michel Angelo in sublimity of character, independently of all passion and emotion. Though the materials of Raffaelle's art are generally borrowed, are they more so than Michel Angelo's? Is not Michel Angelo as much indebted to Luca Signorelli and the Campo Santo, for his choice of subjects in the Sistine, as Raffaelle is in the Vatican? This does not invalidate their genius; whilst their predecessors were the root, the stem, the leaves, and the bud, they were the full blown flower. Michel Angelo was a great genius, and so was Raffaelle; but each owed his genius to a power totally independent of the other. Their geniuses were equal, their temperaments different. Raffaelle was at the mercy of pleasure; Michel Angelo disdained it:

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Raffaelle was made for society; Michel Angelo despised it. In Raffaelle's works there is a geniality of soul with which every man's and woman's heart beats in sympathy; whilst we have no sympathy with the characters of Michel Angelo who overwhelms our imaginations, but never touches our hearts. We are awed by his Sibyls, but we could never think of loving them; and his demons are surely unworthy of the fiery solitudes of hell. How could Ariosto say of him,

> "Michel, piu che mortel,
> Angel divino;"

and then herd up Raffaelle with Sebastian and inferior men; Michel Angelo was perhaps the more moral man of the two, but not the greater painter.

Vasari and Condivi would never have been allowed to publish their falsehoods, as Lanzi says, had Raffaelle been living; but where were Julio Romano, Luca Penni, and Polidoro, whom Raffaelle had raised from a mason's boy to a great painter? Where were they? where were his "dear pupils?" "Let no man," says Johnson, "look for influence beyond his grave." Vasari asserts that Michel Angelo, in flying to Florence, when he quarrelled with Pope Julius II., left the keys of the Sistine Chapel, which he was then painting, to Bramante, Raffaelle's uncle, who dishonourably let in Raffaelle; and that the latter, on seeing the grand design of the prophets, changed his whole style. This absurdity was current in Europe for two hundred and fifty years, till Lanzi, with his usual acuteness, opened the eyes of the world. Would any one believe, that when Michel Angelo fled to Florence, it was in 1506, years before Raffaelle ever entered Rome, and four or five before the chapel was ever begun or painted? It may be presumed that Raffaelle did not surreptitiously derive any advantage from works four years before they were conceived or painted; and we conceive that Bramante could not give Raffaelle the keys to open a door which was never locked, especially as Michel Angelo did not leave any keys, if ever he left them at all, till four years after the time Vasari dates as the period. The prophet Esaias which Vasari says shewed an alteration of style in consequence of the stolen views of works which were not in existence, was painted one or two years before Michel Angelo touched this very chapel. So much for Vasari's sacrifice of Raffaelle to the great Dagon of his idolatry; and so much for Reynold's absurd and unthinking assertion, that "but for Michel Angelo, Raffaelle would never have existed." Vasari's is a delightful book, and all his principles of art are sound, for they are the result of conversations with the greatest men; he was most intimate with Michel Angelo, and Titian, and all the great artists of the day, and constantly in their painting-rooms, at their tables, and in their society.

In the first years of Raffaelle, his feeling was so completely Perrugino's, that it was almost impossible to distinguish their works; though there is a difference in feeling, and that difference is in favour of the pupil. In the Louvre were three of his early works of cabinet size. The Annunciation was one of these; and more grace, innocence, or sweetness, were never put on canvass. Raffaelle's pencil seemed always to melt when he approached a woman or an angel. What an age of genius this was, and how nearly all the great men seemed to come together. Da Vinci was born in 1452, Bartolomeo in 1469, Michel Angelo in 1474, Titian in 1480, and Raffaelle in 1483.

In a rapid and concise history of art to detail the inferior names, who gradually by little and little, conduce to the ultimate expansion of genius, is impossible. A historian of this description has only time for leading points, or headlands in the voyage; he has not leisure to dive into every little cape, bay, and projection, which by degrees, push the mainland into the ocean. The older painters of the Roman school will not add much to the interest of the art; and a fair estimation of Raffaelle and his glorious school, is much more likely to benefit the student, and instruct the general reader. It is not, on the whole, morally just; but many eminent men become thus swallowed up in the blaze of their successors. As Shakespeare nearly deadens all feeling for previous excellence, so does Raffaelle, though Shakespeare, Michel Angelo, Raffaelle, and Titian were all indebted to their predecessors.

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If Julius was adapted for Michel Angelo, Leo X. was peculiarly so for Raffaelle; though Mengs says that the honours and indulgences he received from Leo, made him luxurious and idle, and that he was not so industrious as during the short reign of his first patron Julius. Yet his rapid advance from the first picture he painted in the Vatican, to the Heliodorus, is extraordinary; and, as according to Vasari, he sent artists to draw for him in Greece, there is no doubt that he had a sketch of the pediment of the Parthenon, before it was blown up, and that the Heliodorus is but a skilful adaptation of the Ilyssus. He was so much overwhelmed by employment and honours, that his latter works in the Vatican were wholly placed in the hands of his pupils, and carried on with the spirit of a manufactory. He was then appointed architect to St. Peter's at the death of St. Gallo, which distracted his thoughts. Incessant application, and incessant thinking of course weakened his delicate frame, nor did the capricious and harrassing attendances on such a court increase his strength; added to which the maddening love of women for one so highly gifted and so handsome, his own devoted passion for Fornarina, and the endless demands on his brain, brought him to the grave at thirty-seven, absolutely borne down, like Byron, by excitement of every description, nervous, bodily and mental. This is the way with the world; they kill a favourite by kindness, and an offender by cruelty.

In some life of him an attempt was made to prove that he caught cold by hurrying from his work to the palace at the Pope's order, and standing while in a profuse perspiration in a draught. But that is no refutation of the previous causes; the question is, what prepared him to be killed by such a cause? Incessant work and dissipation; no painter can do both. Of course princes must be obeyed at any expense; they seem to feel little for their dependants, as if in revenge for being themselves deprived of so many enjoyments by ceremony and etiquette. Napoleon used to take great delight in never suffering old German maids of honour with fifty quarters in their arms to sit in his presence.

His last work, according to Mengs, was his Transfiguration in oil, a work deficient in masterly execution, and having a laboured look of smoothness. In drapery, in character, and in expression it was fine; but in the Louvre it looked small. By the side of Corregio, it seemed hard; by that of Titian, raw; by that of Tintoretto, tame; and the Christ's head was not equal to Corregio's at the National Gallery. It was not an example to hold forth to a young man as faultless. The Cartoons at Hampton are finer in point of execution alone; they are his finest works for all the requisites of art. He was not restrained by designing for tapestry; his genius was put forth with a Venetian power of brush; and there are heads equal to any, especially the frightened woman's head in the Ananias, in these wonderful works.

In beauty he was far inferior to the Greeks; in form he could not approach them; in composition he was perfect; in expression, deep; and in telling a story, without a rival. Taking into consideration all the great men in modern art, this young man, not highly educated like Rubens, must be placed on the throne, till one arises who shall have what he had not, in addition to his own perfections; and that young man will probably arise in Britain. He was an extraordinary creature; modest, timid, and amiable; affectionate to his equals, and gentle to the highly-born, his premature death gave a shock to Rome, which those only

Painting. can estimate, who know the depth of Italian sensibilities. But did he die too young? Not at all. He might have decayed, or he might have become more luxurious and more neglectful. No man dies too young who dies with all the sympathies of the world unexhausted about him. The *furor Raphaelis* is the best species of fury that can seize a young student. He has no manner, no affectation, no vice, no grand style; all is simple, natural, and unaffected. His women are creatures of gentleness and love, though none are perfectly handsome. Perhaps he was more adapted for the characteristic heads of apostles than the naked forms of Greece; in fact he was a great Christian painter, and seemed born to extend the influence of Christianity by his art.

His father being a painter, he began early of course, and at sixteen, had painted a picture at Castello, the composition of which was in advance of the age. At seventeen he painted another of the Virgin and child. In the Sacristy, at Sienna, he assisted Pinturichio with designs; in 1504, he went to Florence, where Michel Angelo and Da Vinci were making a great noise with their cartoons for the hall; he studied both, and improved his perspective and colour, in connexion with Bartolomeo. When Bramante, his uncle, who was architect to the Pope, advised his Holiness to send for Raffaelle, the pope consented; and in April 1508, Raffaelle entered Rome, and was admitted into the Vatican.

From the continual occupations of Raffaelle in his art from boyhood upwards, he could not have had a classical education to any great extent. He knew a little Latin, as all Catholics did; but he was intimate with Bembo, Castiglione, Ariosto, and Aretino; and these men must have helped him in historical or philosophical knowledge, or moral allegory, for the completion of his great works. Raffaelle left a noble school; and as soon as grief for the loss of their master had subsided, his pupils set about completing the works he left unfinished. The battle of Constantine was done by Julio Romano and Perino del Vaga. As Raffaelle lay in state, the Transfiguration was placed at the head of his coffin.

Julio Romano. Julio Romano was the most eminent of his pupils. With vast poetry of mind, he did things in a style of execution, which renders him the purest poet in his art. His sun setting, and moon rising over our heads, in the Palazzo del T, is nowhere equalled or approached. Though he put forth his genius at Mantua, he was a Roman in practice, and to Raffaelle owed the elements of his art. His colour was crude and his execution harsh; yet no one can fail to see in his works, the real poetry of painting. Polidoro was another great man of the same school. He was originally a mason's boy, and used to prepare the walls for fresco; but he got interested in seeing the young men at work, tried to draw himself, and Raffaelle having assisted him, he became an eminent painter.

It is interesting to reflect on the affection with which Raffaelle was surrounded. He never went to court without being attended by fifty gallant artists. Little must he have made others feel his superiority; and for once a man of genius seems to have made envy smile. Though there is an instinct in the world, the moment a man of genius appears, yet it depends upon himself whether he is received as a blessing or an annoyance. Mankind will assault the man who attempts to command by superiority, instead of leading by courtesy; but they will hail him let his superiority be what it may, who seems willing to help his inferiors with kindness, or supply their want of knowledge, as if they were doing him a favour to listen. The whole of this is based on goodness of heart, tender sympathies, and a consciousness without the appearance of conceit.

Decline of the Roman school. The glory seems to have gone from the Eternal City after Raffaelle's death. In 1527, Rome was stormed and taken by foreign soldiers. The savages bivouacked in the Vatican, and injured the frescoes by their smoking and fires. Sebastian del Piombo attempted to repair them after the soldiers were gone; and Titian, when in Rome, not knowing Sebastian, actually asked him who had been spoiling those beautiful heads? The art went on sinking rapidly till 1595. Raffaelle had been dead seventy-five years; Giorgione, eighty-four; Corregio, sixty; Michel Angelo, thirty; and Titian, nineteen. When the usual apprehensions of getting on a lee-shore seized the patrons and the artists, and the usual signal of distress was hoisted, Muziano, a pupil of Titian, founded St. Luke's Academy in order to raise a new batch of Raffaelles and Corregios, and save the noble vessel. The only man who since dazzled for a moment, was Michel Angelo Caravaggio. He had great and original talent, though founded on common nature, without any abstract notion of form, any conception of beauty of women, or any refinement in anything. With a sledge-hammer for a pencil, he seemed resolved to batter down all opposition; and by fierce extremes of light and shade, bearded men, dead Christs, and Transteverine beggars for apostles, he founded a school, got a character, and raised a name, which cannot be forgotten in the art of Europe.

Lanzi seems to class in the Roman school every body who practised there for the last three hundred years, but that is not fair. On this principle, all the Flemings, Dutch, Germans, Russians, Spaniards, and English, may be of the school, because they studied there; and Rubens, Vandyke, Velasquez, the Caracci and their pupils, as well as our Reynolds, were, on the same principle, of the Roman school. About the seventeenth century, this eminent school, in spite of the academy of St. Luke, went on declining. Birth, destruction, and reproduction seems to be the principle of every thing physical, but not of moral or mental powers. Lanzi attributes this decay to any cause but the right one; namely, the *absence of genius*, the great primary cause, and which no academy can ever supply.

Cortona, Bernini, and Sacchi. Cortona, Bernini, and Sacchi, were the heroes of this day; and at a later period appeared Carlo Maratta. Raffaelle became to him a substitute for nature; though in 1689, he gave sufficient tone to art, to induce Clement XI. to employ him. But here, as well as elsewhere, genius was wanting. Carlo was as heavy as the lumbering folds of his own drapery; and so insipid are his large pictures, that it is a question whether they did not generate in Europe a contempt for large scripture subjects, which has lasted ever since. However, imbecility had not done spawning; and in a faint struggle for offspring against nature, out came Pompio Battone, and Raphael Mengs. To complete the farce, academies began to be founded in France and in the rest of Europe; and Pompeo Battoni, and Raphael Mengs may be looked upon as a very fair sample of what academies can produce, have produced, and will probably produce to the end of time. Mengs was every thing but a man of genius. He was a bad painter and a deep critic; and his predicting that we had not the works which the ancients esteemed the most, was verified, in a most astonishing manner, by the discovery of the Elgin marbles. The prediction does honour to the sagacity of Mengs. Thus end two great schools of form, conception, expression and composition; the Florentine and the Roman. But of these the Roman was unquestionably the greater.

Venetian school. We now come to the Venetian, a great school of colour, light and shadow, impasto, and execution, completing the imitation of reality; and in summing up the character of Italian and Greek art, we shall see that these components of imitation, each of which characterised an Italian school, were combined in all schools, as a necessary requisite in the perfection of Grecian imitation.

The most ancient work of Venetian art known, is in Verona, in the cellar of a monastery, (Santi Nazario a Celso). It is inaccessible to the public, but can be seen in the woodcuts of Dionisi. In the part which formed the oratorio of the faithful, has been painted the mystery of redemption; it is a

Painting. work of 1070, when the Doge Silvo invited Grecian mosaic painters to adorn St. Mark; men who though rude in art, could nevertheless paint. Thus commenced the art in Venice, whither, after Constantinople was taken by the Venetians in 1204, Greek painters and sculptors, as well as orefici, flocked in crowds.

In the thirteenth century, painters had increased so much, that a company was formed, like the English constituent body to which Hogarth belonged, and laws and constitutions were made. Things were proceeding in this train when Giotto, returning from Avignon, painted at Verona and Padua. Nothing of his, however, is left in Verona; but at Padua the remains of his works are still quite fresh in fresco, and full of grace and vigour. Such was the early beginning of this great school, in which it will be seen that Greeks, as usual, had the first hand. Various names sprung up in this period, but the Bellinis are the most important. One of them was engaged by Mahommed II. and by his talents upheld the honour of the Venetian name; another was the master of Titian and Giorgione, two of the greatest names of the Venetian school.

Giorgione. Giorgione was a great genius; and his execution was entirely above vulgar prejudices. He saw and seized the leading points of leading objects, and hit them with a touch and an impasto, of which he had no previous example even in Leonardo. His breadth and tone were beautiful; and he first opened the eyes of Titian to the superior value of breadth and touch, as compared with over-wrought labour and smooth finish. Giorgione died in the vigour of his life, to the great loss of the art; for there is no knowing how much farther he would have carried his principles, or how successfully he would have disputed the crown with Titian. Lord Carlisle has a small picture by this eminent man, of a youth buckling on the armour of a knight, which is exquisite in tone, brilliancy, depth, and feeling; and had he not been cut off by the plague, there is no knowing how far he might have gone. He certainly first opened Titian's eyes to the value of breadth, and that comprehension of mind required to seize the leading characteristics of objects by a touch, leaving the atmosphere to finish at a given distance. After his death, Titian was without a rival. This great painter began, of course, like all Venetians, to paint directly from nature, without having previously dissected or drawn; nor was he sensible of this error of the Venetian school, till coming to Rome and seeing the works of Michel Angelo, Raffaelle, and the antique, he, like a great genius, set about remedying his deficiency; and the perfection of this union of form and colour is seen in his greatest work, Pietro Martyre, any attempt to move which from Venice, the Venetian senate decreed should be punished with death. This picture occupied him eight years; and eight years were well spent in such a production. The terrific gasping energy of the assassin, who has cut down the monk; the awful prostration of the monk, wounded, and imploring heaven; the flight of his companion, striding away in terror, with his dark mantle against a blue sky; the towering and waving trees, the entrance, as it were, to a dreadful forest; the embrowned tone of the whole picture, with its dark azure and evening sky, the distant mountains below, and splendid glory above, contrasting with the gloomy horrors of the murder; its perfect, though not refined drawing, its sublime expression, dreadful light and shadow, and exquisite colour; all united, render this the most perfect picture in Italian art. Why does not one perfect work entitle a man to rank as highly as a series of imperfect works, like the Capella Sistina? The answer is, because there is greater range of capacity shewn in a series of conceptions to illustrate a theory, than in the completion of one work alone, although all the component parts may be perfect; and Raffaelle, and Michel Angelo, will ever rank higher than Titian, Painting. as Polygnotus will rank higher than Protogenes or Apelles. Prolific thinking, is surely of more value than intensity of imitation, though intensity of imitation must be added to realize the idea of a perfect painter.

Titian began in the style of his master Bellini, with the Titian. most minute finish; a capital basis for future practice, if a man have comprehension to know when to leave it, as Titian did. To shew the young artist that it is never too late to improve, let him compare the Bacchus and Ariadne in our National Gallery, when he could not draw finely, with the Pietro Martyre when he could. In modern art, he was the only painter who hit the characteristic of flesh. Every great painter's flesh is paint; Titian's had real circulation of blood under the skin. On comparing the Ganymede, in our National Gallery, fine as it came from Titian's pencil, with the Theodosius by Vandyke, which is close to it, as fine a specimen of Vandyke's fire of brush as can be seen, the heavy leathern look of Vandyke's colour excited astonishment. In the flesh of Ganymede, colour, oil, brush, and canvass, were all entirely forgotten; it quivered, it moved with the action of the limbs. In Vandyke, the materials of art are uppermost; you think of them, you wonder at the touch, you forget the subject, the expressions as it were scenting of the painter's room and the easel. And so you do with all the Flemings, but never with Titian. Though we have fine Titians in England, the Diana being at Lord Egerton's, and a head at the Duke of Sutherland's; yet it must be confessed, that the Louvre possesses Titians more perfect, especially the entombing of Christ. In Josephine's collection at Malmaison, there were a Venus and Cupid, as perfect as our Ganymede, and not injured by *restoring*, the fatal propensity of the French. In Titian whenever you see the blues sober and in harmony, the picture is uninjured; whenever you see them harsh and too brilliant, they have been rubbed, and the last tone has been taken off.

In colour, he was never equalled; in execution of the brush, he was quite perfect; and in character and expression of portrait he was like Reynolds elevated and sublime; but the dullness which portrait, if perpetually practised, engenders in the capacity to idealise and elevate, rendered his conception of poetical characters defective. Nothing can exceed his Aretino, his senators, and his popes; nothing can exceed Sir Joshua's Lord Heathfield and Mrs. Siddons; but nothing can be meaner than some of Titian's attempts, like Raffaelle, at high poetical expression, except some of Reynold's heads in the Beaufort. The nerve and beauty of the colour in Diana and Acteon are so touching, that one can almost fancy one hears the water ripple and the leaves wave. Glazing was the great feature in his tone, as it was in that of Apelles; and there is no perfect colour without it.

The first requisite in fine colour is the ground or preparation spread over the canvass to receive the colours. It is either of a nature to absorb the oil, or to resist the absorption. If it resist the absorption of the oil out of the colour put on it, it is an oil-ground; if it absorb the oil, it is a water-ground. And it has long been an interesting question, whether the Venetians used an oil-ground or an absorbent ground; whether, like the Greeks, they worked in tempera, and varnished out, or whether they judiciously mingled both oil and tempera together. One would think that Vasari, living as he did with all the great painters, could not be ignorant of their various methods of practice. In 1567 or 1568, he called on Titian, saw him, staid with him, was in his painting-room, and must have talked on art, and perhaps dined or supped with him.[1] But Vasari distinctly says, in a sort of recipe-introduction to his lives, (edition 1568) "that the ground on wood was *gesso*, plaster of Paris; that

[1] All the great painters seemed to prefer *supper*. In Tichozzi, Titian seems to have been a sociable man, and there are extracts from Titian's and Aretino's letters, alluding to pheasants, and presents of birds for the *next supper*.

Painting. then they mixed three colours, white, yellow, and amber, and spread them equally over the white ground; and that after tracing their cartoons, they painted their pictures." A more abominable ground never was mixed; to those who have an organ of colour it is an absolute emetic; and though it might have been Vasari's and the Florentines' ground, it never could have been endured by the eye of a Venetian. "This was the method," says Vasari, "for pictures on wood; but when canvass became the fashion, gesso being likely to crack in ceiling, they made a ground of flour *(farina)*, white lead, and nut-oil, after the canvass had been smoothed by size."[1]

Now when this was published, Titian, Tintoretto, and Paolo Veronese were alive and all at work; and it is but common sense to conclude, that had it been false, they would have contradicted it. Vasari concludes with saying, "So are painted all the great works in St. Mark's Place, Venice." In that place was the Miracle of the Slave, by Tintoretto, afterwards seen by every body in the Louvre. Lanzi says, that the Venetians preferred canvass, but that at first they painted in tempera, and then came oil-painting, which the Venetians first adopted. On the arrival of the Bacchus and Ariadne in England, a little bit chipped off at the corner showed the ground underneath to be of the purest white. Now, if a white ground is absorbent, it sucks the oil out of the oil colours, and becomes the colour of oil. Sir Humphry Davy said to the author of this article in 1823, that in process of time oils become varnishes; and it is not impossible that the white ground of Titian may have been absorbent, and though it had sucked out the oil in the course of three hundred years, it may have recovered its original whiteness. The author's experience extends only to thirty years, and in that period an absorbent ground which sucked out oil has never recovered its whiteness.

But, if the Venetians painted first in tempera upon the white ground, and finished in oil, the tempera intervening between the last painting and the ground would preserve the ground white; and as Titian's method of proceeding was gradual and progressive in successive layers, like that of Protogenes, so that each layer became a help to the succeeding one, there is no reason to doubt that tempera might have been the first impasto. In parts of the Pietro Martyre, there certainly was the crude look of tempera preparation, softened by a glaze, especially about the projecting leg of the assassin. That the basis of Venetian pictures was a white ground, there can be no doubt; like the intonacos of Apelles, and the plaster-grounds of the painted mummy-coffins of Egypt. Tintoretto and Bassano used dark grounds to save trouble; but they are ruinous. They come through the thin half-tints of the picture, and render it distinct masses of dark and light, like most of the Lombard school. Many of the works of Paul Veronese, who painted one hundred years before, were in perfect preservation in the Louvre, whilst a number of the Lombard pictures were gone. The white ground was the "luce de dentro" of the Italians, "the light within." Upon this beautiful white ground they placed their colours purely and crudely, and then by spreading thin transparent tones, took down the rawness, without losing the force of the tint. This was the practice of the Greeks, and is also the present practice of the British school. When Cicognara, the president of the Venetian academy, was in England, he remarked to the author on the singular fact, that the British was the only school of colour left in the world, though our climate was the worst; and such was the state of Venice some years since, that an English consul could get nobody to paint the king's arms for him, and being the son of a painter, he was actually obliged to paint them himself.

As an example for the student, Titian is perfect. His execution never attracts by itself alone, but as the vehicle of the object it imitates. In colour he is never gaudy, never black in light and shadow, never forced or affected, and in drawing, latterly, grand. In composition he was not so perfect nor so fertile as Raffaelle; but in the imitation of flesh, no other artist in the world, except Apelles perhaps, could rival him. As a painter of portrait and landscape, no one has surpassed him. He did not grace his senatorial heads with the beauty of the backgrounds of Reynolds or Vandyke; but the absence of all gaiety behind the heads, perhaps added to the sublimity of their expression. It is curious to read in Boschini's little work, that young Palma, who had it from old Palma, a pupil of Titian, told him that Titian very often finished with his thumb. Palma distinctly says, that he has seen Titian put on with his thumb and fingers masses of colour which gave life to a picture.

In a word, neither of the great Italian schools showed the sense of the ancients. The Romans omitted colour and imitation from sheer accident; the Venetians drawing and form; and Reynolds, without going into the causes of these mutual deficiencies, laid it down as a principle, that colour and reality were incompatible with high art; whereas, when each school found out its deficiency, each endeavoured to correct its peculiar defect.

Tintoretto. The giant of Titian's school was Tintoretto, who gave such early indications of self-will and genius, that Titian, mean and jealous, turned him out of the house. Raffaelle would not have done this; he did not turn out Julio Romano. But Tintoretto was not to be crushed by the bad passions of his envious master; and took it very properly as an evidence of his talent. And what did Titian get by his paltry meanness? Nothing but pity. Tintoretto, young as he was, immediately formed a plan of his own, for combining the drawing of Michel Angelo with the colour of Titian. He devoted the day to the one, and many parts of many nights, and often whole ones, to the other. In a few years, the result was the Miracle of the Slave and the Crucifixion. Although the execution of Tintoretto looked daring and impudent by the side of the modest, senatorial dignity of Titian, yet there was a grand, defined dash about it. The original sketch of the Miracle of the Slave, is in the possession of Rogers the poet, and is a very fine thing. Every body speaks of the Crucifixion as a wonderful instance of power. But in colour it is lurid and awful; in expression, character, and delicacy of feeling, discordant and offensive. His pictures seem to be a mass of fore-shortenings, affected twistings, dashing darks, and splashing lights, with a hundred horse-power of execution; bearded heads, Venetian armour, silks, satins, angels, horses, architecture, dogs, water, and brawny-armed and butcher-legged gondoliers, without pathos, passion, or refinement. He used to put little models in boxes, and light them in different holes, for effect. Like all Italians, he was accustomed to model and hang up his models by threads for fore-shortening. His style of form was a mixture of the pulpiness of the Venetian, and the long, anotomical, bony look of the Florentine school. He cannot be depended upon for correctness of proportions, but he was a grand and daring genius; and his conduct, when oppressed by Titian, should ever be held up as an example for the aspiring youth, when trodden upon by his elders.

Paul Veronese. Whilst Tintoretto was astonishing the Venetians by his daring, which made even Titian tremble, Paul Veronese, the other great contemporary, was mildly pursuing his azure and beautiful course. Of a nature the reverse of Tintoretto, and not equal to him in sublimity or terror of conception, he yet gave equal evidence of being run away with by his brush. Ceilings, canvass, halls, walls, and palaces, were so many proofs of his power. His greatest work is at Paris. It is the Marriage of Cana, a wonderful instance of executive power;

[1] This is Vasari's account, pp. 51, 52, 53, Firenze, volume i. 1568.

Painting. but here all story, sentiment, and pathos, are buried in the noise, bustle, eating, drinking, and fiddling of a Venetian city feast. Paul Veronese was certainly the most corrupt painter of the time.

Cannaletti, &c. After these great men, the art began to decay; and Paul Veronese and Tintoretto gave symptoms of a conventional mode, which, when taken up by inferior men, hastened its ruin. Down to the present age, with the exception of two or three mannerists, no name occurs worthy of eminence or selection. Cannaletti was a genius in his way. Sebastian Ricci, and Marco Ricci, were much employed in England to disfigure ceilings and palaces by wholesale, with gods and goddesses, in subjects allegorical, poetical, mythological, and nonsensical, to understand which it required pages of explanation, and to see which a nine-feet telescope by Dolland. Montague, Burlington, and Bulstrode houses, are signs of the infatuation of the English nobility at that time; an infatuation, however, which shewed a disposition to employ art as it had been employed in Italy, and if the genius had been equal to the opportunity, the result would have been different.

Lombard and Parman school. The next school of any importance is the Lombard school, which comprehends the Mantuan, the Modenese, the Cremonese, and the Milanese. Andrea Montegna is the hero of the Mantuan school, and Vasari says, that his master-pieces are the tempera designs which we have at Hampton Court. They are fine things; Rubens used them; and they are a mine of costume, though the forms have too much the look of the model. Julio Romano's great work is at Mantua, yet he must be considered as a Roman. The works of Montegna were, as Lanzi says, the greatest effort of the last style before Leonardo da Vinci introduced a new one, which overturned the Gothic. After Julio Romano, the art decayed, and then of course came the old story, "Una accademia per avvivarla." This academy has been splendidly kept up by Austria, and, as usual, has not produced a single man of great genius in three hundred years.

Corregio. Contiguous to the Modenese school is the Parman; and now we come to the most unaccountable and delightful of all painters, Corregio. When it had been determined to ornament the great cupola of St. John, Corregio, though then a young man, was selected to paint it; and, like Raffaelle, his genius expanded with the opportunity. After Raffaelle, Titian, Michel Angelo, Da Vinci, and Bartolomeo, who would have thought that another style, independent of either, and unlike any thing else in the world, could have burst out? But so it was. Of all the painters that ever lived in the world, there is no accounting for Corregio. Unlike Greeks, Romans, and Italians, out he came into the world, in colour, drawing, light and shadow, composition, expression, and form, like nature, and unlike every body else, who ever studied nature at all. Michel Angelo, Raffaelle, Titian, we can trace; we see upon whom they were grafted, when they budded and burst forth. But who is Corregio? Nobody is certain. One swears he was poor, another that he was well off; another says he died in consequence of a fever which he caught by carrying all his money in copper, the price of a picture; another protests it was no such thing. Meng's account is the best, and Vasari's mostly without authority.

There is no certainty that his portrait is in existence; in fact there is as much dispute about it as there is about Shakespeare's; and here are his beautiful works, his Notte, his Catherine, his Christ in the Garden, his Magdalene, his Venus and Mercury, and his *Ecce Homo* in the National Gallery, the only head of Christ in the world. This head of Christ ought to be reverenced as the identification of the character, as much as the head of Jupiter by Phidias was in the Pagan world. There is no Christ's head by Raffaelle which at all approaches it, either in the Transfiguration or in any other work; and the head by Leonardo da Vinci in the gallery cannot be endured after it. Of all painters, he astonishes one the most. If any fault is to be found with him, his men have a touch too effeminate. His colour is exquisite; his light and shadow are enchanting, but his forms defective; his composition is simple and infantine; his expression unimpassioned, but sweetness itself; and when sorrow or suffering was to be represented, who ever did it more tenderly than Corregio? Let any man who doubts this, dwell for a moment on the gentle suffering, and the feminine yet manly beauty of the Christ above mentioned. It is the very Christ who commanded by submission; without weakness beautiful, without effeminancy tender; without taint the personification of love. His hands, his shoulders, his beard, his hair, belong to that divine being who vanquished sin, by yielding to torture. It does not seem painted, but as it were spread upon the canvass by an angel's breath. His men look as innocent as girls; his women as guileless as infants; and his infants as if they had just come from the skies.

Painting.

In the cupola at Parma, the great wonder is the foreshortening; and in the mouths of the vulgar this is technical perfection; whereas there is nothing more purely mechanical, nothing in fact you can so easily teach. One single smile of Corregio's angels, one touching look of Raffaelle's apostles, the sentiment of the Duke de Lorenzo by Michel Angelo, one crimson tone by Titian, are worth all the foreshortening on earth. The greatest excellencies of Signorelli, Buonarotti, and Corregio, are said to be their foreshortenings; whereas the greatest excellencies of Buonarotti and Corregio are not their fore-shortening at all.

In spite of the perfections of this wonderful man, he founded as it were the decay, "le commencement de la fin." His breadth in fresco produced Lanfranco, Cortona, and Giordano, who covered Italian palaces with the *sweeping* brush of our patent chimney-cleansers, beginning it in the morning, finishing it by the evening, standing on the floor, and disdaining a scaffold, previous study, or previous thinking; and others came who bedaubed the palaces of Europe with clouds like feather-beds, cornucopias and Jupiters, till one's brain aches in thinking of them.

Reynolds was immensely indebted to Corregio; for Rembrandt and Corregio are certainly the bases of his style. One of the most beautiful works in the Louvre was the Marriage of St. Catherine, which when once seen haunts us in after life in dreams. In a word, Corregio was an angel that passing this earth in its flight, drooped its wings and dropped upon it, to give us a foretaste of the smiles which welcome a happy spirit in a purer sphere.

Parmegiano is the next important name in this school, who grafted the grace of Corregio on the affectations of Michel Angelo. His greatest work is in our National Gallery; the Vision of St. Jerome. The Christ is a beautiful boy, but affected; the Virgin is Michel-Angelesque, having the *glumdalclitch* look of his Brobdignaggian women. St. John is finely drawn, but not unexceptionable; and the St. Jerome is sleeping in a position as if he had got into a cramp in the first part of the vision, and could not get out till it was over. It is raw in colour, skinned in construction, and spoils the composition altogether. His small pictures are beautiful but long in proportion. His fingers seem always to move to music; and his limbs to be conscious how gracefully they are disposed. He has often been a fatal example to the young. Nor is his Moses, whatever Gray may say of it, an instance of the sublime. The expression is mean, and the form overdone. Parmegiano died, like Raffaelle at the age of thirty-seven, when all that was expected of him had not been realised, and when, if he had lived longer, perhaps he would have done worse.

Parmegiano.

In 1570, the best Corregieschi were grown old or dead, and the school of Parma began to give way to that of Bologna, the truly great academical school. This was not an academy in the modern sense of the word; it was a school, and nothing but a school, without distinctions, and managed

School of Bologna.

Painting. by directors; and it is the only academy which has ever produced any genius. Dominichino, Guido, and other names of the second period, came between unrivalled excellence and approaching destruction, and stopped for a little time the decay of the art.

Of the Cremona school, there is no great name. In the Milanese school, Da Vinci seems the hero; he founded an academy which, according to Lanzi, was the first in Europe that reduced art to rules, the works of Leonardo being the canon. His great work is in the refectory. But fifty years afterwards Aramini says that it was spoiled; in 1642 Scannelli writes, that it was with difficulty made out; and Barry ultimately saw it destroyed by a *restorer*. When Eugene Beauharnois was viceroy of Italy, he drained the refectory and had it paved with tiles; and it is said in a report, that the colours began to revive. Da Vinci's academy having produced no talent, Maria Theresa founded another, which, though full of casts of every description, has nevertheless proved equally unsuccessful.

The Caracci and their pupils were the last crop of genius which Italy threw up, and though they were second-rate, they came of the breed of the great who were no more. The style of Michel Angelo seems to have taken early root in Bologna, perhaps from his executing in that place the statue of Julius II. Giotto, in the first instance, excited emulation by flying about Italy; but he seems to have scattered everywhere the seeds of art, and Tibaldi, after having studied in Rome, certainly founded this style at Bologna. The first school formed was by Bagna Cavallo, and Primaticcio. It failed in 1564; upon which Primaticcio went to France, and Tibaldi to Spain, and the art was of course neglected.

The Caracci succeeded them and were extraordinary men; but what would they have done if Raffaelle, Michel Angelo, Titian, and Corregio had never lived? They saw nature only by the help of their great predecessors. Whatever the Caracci did had the appearance of labour; whilst whatever was done by their great predecessors, had an air as if there was something that no labour could attain. Ludovico had more feeling than his brothers, and had the honour of being instructed by Tintoretto. They were the sons of a tailor, and founded an academy in their own house. Agostino principally engraved, and Annibale principally painted; but they each contributed instruction to the school in which were formed Dominichino, Guido, Lanfranco, Guercino, and Albano.

Guido, Guercino, and Albano. The greatest genius of the school was Guido; but he was envied by the Caracci; and even in this school the vices of an academy began to appear. We did not find Raffaelle sowing discord amongst his pupils by putting one against the other. Albano was opposed to Guido. Dominichino was an eminent but heavy genius; and his communion of St. Jerome is a fine thing though dull. There was a vulgar grandeur about Guercino, and an insipidity about Albano. The great work of Annibale Caracci is the Farnese gallery, which is excellent in every thing, but nerve and genius. Say what you will about the Caracci, there is a want in their art, which affects the pen of him who is attempting to do them justice. They lived together, did not marry, and were ill paid and ill-tempered; like all old bachelors they were discontented, they did not know why, and fidgety, they did not know for what; they envied the talents they were desirous of bringing forward, called the art their "wife," and were never satisfied, living in a perpetual fret of teaching, and painting, and complaining. Annibale became dissipated and died early. It is an extraordinary feature in the moral character of the Italian artists, that the greater part did not marry, and hence came the cant "of the art being their wife," with the natural consequence, that girls who had been models generally ended by being mistresses.

The Caracci kept up this affectation, they said the art was their "cara sposa;" and to all the confusion of a bachelor's house, added the slang of a mere painter's habits. At the dinner-table, crayon and paper were always at hand to catch attitudes, actions, and expressions, and groups; as if expressions and attitudes could not have been remembered in the solitude of the study, and kept till wanted with just as much effect as this vulgar intrusion on the usages of society. A great artist is always a man of the world; an inferior one a man of the palette. Raffaelle, Titian, Angelo, Rubens, and Reynolds, would have passed a twelvemonth in any society without being discovered to be artists; but the Caracci would have talked of tone and touching during the first half-hour. A genteel woman, accidentally travelling in a coach with three artists who were *palette-men*, expressed afterwards her wonder and suspicion as to the state of their intellects. For after the usual dead silence, one of them said, with an air of vast profundity: "How finely the white sheet in the hedge carries off the colour in the sky." "And look at that old woman's cloak taking up the brick-wall," said another. "Yes," said the oldest of the set, "how finely it was done yesterday by a red night-cap in a pretty bit of Sir George." Johnson used to say, "Sir, we were reduced to talk of the weather." But even the weather is preferable to this detestable affectation. Though the deepest principle of the ancients was the preservation of beauty in everything, they never sacrificed beauty to expression, but always combined the two; whereas Guido, by an eternal repetition of the expression of the Niobe in Christs and Virgins rendered the preservation of beauty at such an expense insipid. The beauty of the Helen and Paris was truly exquisite; but hundreds of Herodias's daughters with St. John's heads, "have a look," as Lord Byron says, "of bread and butter." His grace was the grace of theatres; his pencil light, airy, and beautiful, though rather careless than masterly. Dominichino, on the other hand, obedient, slow, and timid, imitated everybody and fell short of all. But Guercino was the most original of the school; his finest manner is his candlelight manner, yet still there is a vulgarity in his forms.

None of the Caracci or their school, had they been born at an earlier period, would have advanced the art one iota beyond their predecessors, so entirely dependent were they upon the great who had gone before. "Such was the state of art," says Fuseli, "when the spirit of machinery destroyed what was yet left of meaning;" when contrast and grouping meant composition and thinking, and a mass of rapid, thoughtless, empty, impudent frescos disgraced the walls, palaces, and churches of Italy. Pietro of Cortona and Luca Giordano are the heroes of this inundation of splashiness; and yet what artists they were! The decay which it announced, was the decay of the giant Italian fresco hand that still struggled to do its duty, whilst the head was fast approaching imbecility in thought. The meanest pupil of the meanest machinist would have swept the first-rate British artist that has ever yet existed into the earth, with his tiptoes and exhibition-glare.

Decline of Italian art. Thus, with the Caracci and their school, ended the greatness of Italian art; nor has there been one single painter of such genius since, from Andrea Sacchi to Cammucini the present hero of the Romans. Rubens, Vandyke, and Rembrandt turned it into a new channel in Flanders; Velasquez and Murillo kept it alive in Spain; Teniers, Ostadt, and Jan Steen preserved it from extinction in Holland; the Poussins, Claude, and Salvator, meanwhile revived it in Italy; whilst the old Gothic masters in Germany, with their colour, and most of them with great invention but in bad taste, were an absolute dung-hill of diamonds and pearls, which everybody has considered himself as having a right to plunder, not even excepting Raffaelle himself. Whilst the art was sunk to the lowest depths in Europe, Reynold's in England broke forth with a brilliancy of colour which

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has rendered it no longer a hopeless attempt to rival the gorgeousness of Venetian splendour. If ever there was a refutation of Reynold's own theory, that "genius was the child of circumstances," he was a living one; in spite of all circumstances, in spite of the utter want of all education as a painter, in spite of all the apathy of the nation, and the extinction of art in Europe, out he came with a vigour and beauty which have ever since defied rivalship in portrait and children.

German school.

The Germans are an extraordinary nation, but always more or less under the influence of a wrong taste. Their early painters are full of thought; and as a proof of what Raffaelle's estimation of them must have been, he adopted almost to the letter, in his famous Spasimo in Spain, Shoengaer's magnificent composition of Christ bearing the cross. The hand leaning on the stone, with the momentary action of the drapery, is in Shoengaer. The brute pulling Christ, in an old German dress, Raffaelle has taken and improved; and he has also placed the Marys in the fore-ground which Shoengaer placed in the back-ground; but the whole of the composition is Shoengaer's, though Raffaelle of course has added to it his own perfections.

Albert Dürer.

Albert Dürer is considered as the greatest man of the German school; but there is nothing which he has ever done that can compete, in expression and composition, with this fine production of Shoengaer's. Fuzeli says, "Albert Dürer was a man of great ingenuity, but not of genius. His proportions of the human figure are on a comprehensive principle founded on nature, and the result of deep thinking." He had sometimes a glimpse of the sublime, but it was only a glimpse. The expanded agony of Christ on the Mount of Olives, and the mystic conception of his figure of Melancholy, are thoughts of sublimity, though the expression of the latter is weakened by the rubbish he has thrown about her. His Knight, attended by Death and the Fiend, is more capricious than terrible; and his Adam and Eve are two common models shut up in a rocky dungeon. "If he approached genius in any part of his art, it was in colour; his colour went beyond his age, and as far excelled in truth, and breadth, and handling, the oil colour of Raffaelle, as Raffaelle excelled him in every other quality. I speak of his easel-pictures; his drapery is broad though much too angular, and rather snapt than folded. Albert is called the father of the German school, though he neither reared scholars nor was imitated by the German artists of his or the succeeding century. That the exportation of his works to Italy should have effected a temporary change in the principles of some Tuscans who had studied Michel Angelo, as Andrea del Sarto, and Jacopo da Pontorino, is a fact which proves that minds as well as bodies may be at certain times subject to epidemic influences."

Flemish school. Von Leyden.

Lucas von Leyden was the Dutch caricature of Albert Dürer; and ere long the style of Michel Angelo was adopted in the same way as by Pelegrino Tibaldi, and being spread by the graver of Giorgio Mantuano, provoked those caravans of German, Dutch, and Flemish students, who, on their return from Italy, introduced at the courts of Prague and Munich, in Flanders and the Netherlands, that preposterous manner, that bloated excrescence of swampy brains, which in the form of man left nothing human, distorted action and gesture with insane affectation, and dressed the gewgaws of children in colossal shapes, in the style of Golzius and Spranger. But though content to feed upon the husks of Tuscan design, they imbibed the colour of Venice, and spread the elements of that excellence which distinguished the succeeding schools of Flanders and of Holland. At this moment out blazed upon the world that giant of execution and brute violence of brush, and brilliant colour, and daring composition, Rubens; and another mysterious and extraordinary being, Rembrandt, who seemed born to confound all theory but that of innate genius, confirmed it for ever. Rubens gloried in the splendour of the rainbow, whilst Rembrandt enjoyed only the poetry and solemnity of twilight; when the evening star glittered, and the sun was down, then was the hour of his inspiration.

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Rubens.

The scholar of Otho Venius, Rubens, imbibed from his master an emblematical taste; he spent eight years in Italy, hurried back at the death of his mother, and painted that wonder of art the Elevation of the Cross, before he was thirty. It is the perfection of a fearless hand and daring brush, conscious of its principle; and though the sweep of Michel Angelo's contours, applied to butcher's backs and coal-heaver's legs, rather increased their vulgarity than added to their refinement, yet the dashing power of that astonishing picture, in spite of its Flemish, pallid, and ugly wretches for women, renders it the bloom of his powers. Rubens was a man of such general knowledge, that the Marquis of Spinosa said, that painting was his least qualification. He was ambassador to Spain and England, and adorned the banquetting ceiling at Whitehall, the centre portion forming an amazing picture. Educated classically, he carried classical feeling into every thing but his art; and after spouting Virgil with enthusiasm, he turned to his canvass and painted a Flemish butcher with bandy legs (if he happened to have such) for Æneas. How extraordinary it is that, relishing as he did, Homer, Virgil, and Livy, he should give Dutch Helens, Flemish Junos, and German Diomeds, for classic art. His greatest work is the Luxembourg Gallery; and for once he hit a sweet female expression in the mother of Mary de' Medicis, after accouchment. One of his finest pieces, the Rape of Proserpine, is at Blenheim, where the Arethusa, as a water nymph, is putting up her hand, with her back towards you. That a man who could occasionally paint with such delicacy, should so often disgust us with his flabby vulgarity, is not to be accounted for. He painted portrait finely, landscape sweetly, and animals with great power, except the lion, whose straight shaggy mane he always curled like the ancients, and lost its noble look. He was a great man, and painted wherever he went. He was diligent and religious; he rose at four, heard mass, and went to his painting-room, where, with little intermission, he painted till five; he then rode, and returned to his friends, many of them the most celebrated men of the day, who were assembled to meet him at supper; at eleven he retired, and again proceeded to work at day-break. It is interesting to contrast this virtuous course of so great a man, with the vulgar infidelity which alone distinguishes the most incompetent in the art; and it is impossible not to conclude, that those whom God has most endowed with gifts, are the most sensible of their own imperfections. Rubens was thrice married, and educated his children highly; one of them wrote a very learned work, *De lato Clavo*, which shews research and learning.

No where did Rubens shine so effectually as in the Louvre. In all the world, perhaps, there never was such a splendid opportunity for studying to perfection the principles of the great men in the art, as was afforded in the Louvre in its full glory; and injurious as the formation of that collection had proved to the cities of Italy, yet Napoleon gave a dignity and an importance to the art, which it has not since lost, by making the productions of its great men subjects of treaty, and receiving them as equivalent to territory or treasure. There you rushed from the Romans to the Venetians, from the Flemings to the Spaniards, from Titian to Raffaelle, from Rembrandt to Rubens, and settled principles in half an hour, which it took others months, perhaps years, to accomplish. It cannot be denied, that in force of effect, Rubens bore down all opposition, from his breadth, brightness, and depth; and let every painter be assured, that if he keep these three qualities of effect, the leading qualities in the imitation of nature, he will defy rivalship in the contest of exhibition.

Painting. Rembrandt, with all his magic, painting on too confined a principle, lost in power, and looked spotty and individual. Paul Veronese and Tintoretto had not that solidity, which is the characteristic of Rubens; Titian seemed above contest, and relying on his native majesty of colour, exhibited a senatorial repose, which gave to Rubens a look almost of impertinence; but still you could not keep your eyes off the seducer, and even if you turned your back, you kept peeping over your shoulder. Here all peculiarity suffered. The silvery beauty of Guido looked grey; the correctness of Raffaelle looked hard; Rembrandt failed most by the brightness of Rubens, the magic of Corregio, or the sunny splendour of Titian; and after wandering about for days, you decided that *he* suffered most who had most peculiarity. With all his grossness, want of beauty, and artificial style, Rubens' brightness and breadth carried the day, as far as arresting the eye, and forcing you to look at him, hate as you might his vulgarity, and his Flemish women, and his Flanders breed of horses.

Rembrandt Rembrandt van Rhyn, was next to Rubens, in point of art, and more than equal to him in originality. Whether in portrait, landscape, or historical pictures large and small, he was like nobody; as wonderful as any, and sometimes superior to all. His bistre-drawings are exquisite, his etchings unrivalled; his colour, light and shadow, and surface, solemn, deep, and without example; but in the naked form, male or female, he was an Esquimaux. His notions of the delicate form of women, would have frightened an Arctic bear. Let the reader fancy a Billingsgate fish-woman, descending to a bath at a moment's notice, with hideous feet, large knees and bony legs, a black eye, and a dirty night-cap,—and he will have a perfect idea of Rembrandt's conception of female beauty. Though his historical pictures are often remarkable for pathos and expression, his characters are sometimes absolutely ridiculous. His Abrahams are Dutch old clothesmen; and yet his Jacob's Dream is sublime beyond expression. Whatever he painted, he enriched; his surface was a mass of genius, and his colour a rainbow, darkened by the gloom of twilight. In portrait, sometimes, his dignity was equal to Titian; but the characters he painted were inferior.

These two wonderful men, each a perfect contrast to the other, revived art; Rubens on the principles of the Venetians, and Rembrandt in defiance of all principles. But the latter sacrificed too much to a peculiarity, and he was punished for it in the Louvre by the side of others.

Vandyke, &c. Rubens produced Vandyke, Snyders, and Jordaens, and a whole host of pupils. Vandyke had more elegance, but not so much imagination; Jordaens more vulgarity, with equal power. Snyders was a mere animal painter, and he carried the touch necessary to execute the hairy skin of an animal, into every thing he did. Vandyke by his splendid portraits, certainly generated a love of art in England, which has never left us, after the destruction of historical painting at the Reformation.

Teniers, &c. Rembrandt had pupils, who were by no means equal to himself. David Teniers the elder was a pupil of Rubens. These two extraordinary men were certainly the founders of the Dutch school; and the great principles of their works were carried by David Teniers the younger, Jan Steen, Ostadt, and Cuyp, into smaller and more delicate productions. A man of the highest ambition and noblest views in art can study with the greatest benefit the dead fish and bunches of turnips, servant girls and drunken boors, for beauty of handling and effects in art. He who looks down on the excellencies of the Dutch school, does so from a narrowness of understanding, and not an enlargement of views; and if an historical painter can see nothing to learn in their little beautiful works, he will not learn much from the greater productions of Titian.

Spanish school. Directly after the Flemish comes the Spanish school, which, not so vulgar as the former, was equally unideal. The Spaniards painted the people about them for all sorts of subjects and all sorts of characters; and they are only more refined than the Flemings because the Spaniards are a more cultivated people. The long possession of the Moors prevented the Spaniards from advancing as soon as Italy. The great schools in Spain have been those of Madrid, Seville, and Valencia. In 1446 Antonio Rincon abandoned the Gothic of the European artists; in 1475 Gallegos was so like Albert Dürer, that he is suspected to have been a pupil; in the sixteenth century riches flowed in, patronage was liberal, and, what is most important of all, genius existed in Spain. Becerra de Baeza, pupil of Michel Angelo, painted in fresco, at Madrid, Salamanca, and Valladolid; and in the Trinità del Monte in Rome, there is also a picture of his. Various painters follow of course in all the schools, till the coming of the real hero of Spanish art.

Velasquez. Velasquez was born at Seville in 1599. He became a pupil of Herrera, and left Seville in 1522, to seek his fortune in the metropolis; where he succeeded so completely as a portrait painter, that he got to court, and having become acquainted with Rubens, often visited his painting-room. Rubens must have been of the greatest use to him. Velasquez then visited Italy, but could not bear the Roman school after the Venetian. In masterly execution and life he surpassed Rubens and Vandyke. Of all the great painters, he seems to have despised the most the vulgar appetite for what is called *finish*, that is, polished smoothness. Every touch from Velasquez is a *thought* calculated to express the leading points of the *thing* intended to convey it. Masterly beyond description, and delightful beyond belief, he conveyed the impressions of life as exquisitely as if his imitation breathed. But so utterly decayed is the present Spanish school, with its pompous academy, that Spaniards when asked how they can reconcile their hideous polish with the freedom of Velasquez, have answered that *Velasquez was always in a hurry.*

Murillo. After Velasquez ranks Murillo, a man of a tenderer genius, but equally alive to life. He has the surface of Corregio and colour peculiarly his own; and he was what the Italians call a *Naturaliste*, indeed, the whole school was of that species. Like Rembrandt and Rubens, the heroes of history are always the countrymen of the Spanish painter. The Prodigal Son is one of the finest works in the Duke of Sutherland's collection; it is beautiful in execution, light and shadow, and colour, but Spanish in character and expression. They never got beyond their model or their country; and this may in a great measure be owing to their masters having been Venetians, though Tibaldi and Torrigiano had visited Spain. Murillo was an exquisite painter, and if he had been soundly educated like the Greeks, would have been as refined in character and form as he is now in colour and handling. He first got an insight into painting from Moya, a pupil of Vandyke. Having sold his pictures to hawkers for what they would bring, he saved money and went to Madrid, and, with the frankness of genius, at once introduced himself to Velasquez, who received him like another Raffaelle. After three years of continued kindness, he returned to Seville, founded an Academy, and for his great work of St. Antony at Padua, he received ten thousand reals. It is said that he covered more canvass than any body else; but after the acres of Rubens in the Louvre, that assertion is questionable. Velasquez and Murillo, of course, came like the rest, *before* academies. One now exists in Madrid, and no genius has appeared since its institution. It is quite ridiculous to see the same results all over the world; and it is still more ridiculous, to find the kings of Europe still continuing to found and embellish these useless establishments.

French school. In France, throughout all the middle ages, the art of design was never extinct, either in mosaic, glass, tapestry, fresco, miniature, or tempera. Though the learned author of the "Discourse Historique" says, that the French were the first who presumed to personify the Almighty in the form of

Painting. man; yet nothing worth remembering occurred till the death of Leonardo, in the arms of Francis I. in 1518, and the employment of Primaticcio, Rosso, and Nicolo del Abbate. Jean Cousin in 1462, and Vouet in 1582, were the first French painters of any importance in this latter period. Simon Vouet, the younger, was the master of Le Sueur, Le Brun, Mignard, and Dufresnoy; he lived in 1600, and the best period of French art was from that time until 1665, the beginning of the reign of Louis XIV. They, as usual, founded an academy, ten years before Poussin's death; and Coypel, Jouvenet, and Rigaud, were the produce of the institution; whilst Poussin, Le Sueur, and Le Brun, had flourished and obtained their reputation before it was founded. Van Loo and Boucher succeeded Jouvenet and Rigaud, and gave additional evidence of the utter incompetence of the academic system. About 1770, flourished Greuze, who began to evince a better taste, and was persecuted by the Royal Academy for his independence, till the Revolution of 1790 put an end for the time to all imposture. Down went the Royal Academy in an instant; and all the conventional distinctions in art, which are generally the cloak of imbecillity, were fluttered off in the whirlwind. The people, long prevented from seeing fine works in the great galleries, now broke into these galleries with brutal exultation. Bloody and dreadful as were the consequences of the first burst of the French Revolution, one of its most beneficial effects consisted in throwing open all matters of art and science to the people. Naigeon, the conservator of the Luxembourg, said, in 1814, that nothing was opened to the people before the Revolution; and we ourselves in England are now enjoying our Museums, entirely in consequence of the effect produced upon Mr. Fox and the English, who visited Paris in the year 1802, and who were astonished at the noble frankness with which the Louvre was exposed.

The academy being swallowed up in the whirlpool of political revolution, the Institute supplied its place. Napoleon, on becoming first consul, sent immediately for David, who had been a furious republican during "le temps de la terreur;" a man of great talent, but of abominable taste. Napoleon made him his court-painter, and gave such preponderance to his influence, that the detestable style of David became everywhere but in England the style of European art. Gros, Prudhom, Guérin, deviated from the rigidity of David's style. Prudhom was a man of genius. Hideous as was the style of David, in fact painted Roman sculpture, it had some foundation in reason. This was, if possible, to bring the French back to classical art, after the flutter of Boucher, and the pomposity of Coypel; but, like all reformers, he went to excess.

The materials for assisting them are so deficient, that the greatest artists have arrived at any thing like an imitation of nature only by the greatest science and skill. It is much easier to paint a button and a chair, than a human face; therefore the great artists dwelt upon the face with all their dexterity, and touched off the button and chair with less anxiety and care. The French used to say, that *theirs* was the system of the ancient Greeks, and that it was *our* prejudice to disapprove of it. But before we have done, we shall show that it was not the system of the ancient Greeks; and as we pay all due deference to the Italians, Flemings, Dutch, Spaniards, and Greeks, and to their own Poussin and Claude, they have no right to accuse us of prejudice because we disapprove of David. We do not deny David's talent, because it must have required talent to mislead the continent of Europe. In art David's expression was taken from the theatre, and his actions were borrowed from the opera house; his forms were Roman and not Grecian, and his colour was hideous enough to produce ophthalmia. If he and his pictures, with all he ever designed, and all he ever invented, had not appeared in the world, or having appeared, had been utterly rooted out of it, the atmosphere would be purer. He is a plague-spot, a whitened leprosy in painting, that haunts the imagination with disgust. This he had the impudence to say of Rubens. But since the peace, and from the connection with England, a better school of colour has sprung up in France; and La Roche gives evidence of having in some degree got rid of the furniture look of David, though it still poisons a French pencil. Painting.

Horace Vernet is a distinguished name; indeed, he may be called the first light-infantry grenadier of European art. He paints a head in five minutes, a whole imperial family in ten minutes, and an historical picture in twenty; and he paints all three with talent and skill. Though the French are not yet *sound* in art, they are the best educated artists in Europe; and if the English would combine their own colour with the careful habits of French early study, and if each school could supply the deficiencies of the other, they would make out a very good school between them.

In thus suffering ourselves to be led away to the present state of the French school, we have omitted to do justice to the great men of former times; Poussin, Sebastian, Bourdon, and Le Sueur. Poussin is the hero of French art. His Death of Germanicus is very fine, as a specimen of history; and his Polyphemus sitting on the top of a mountain, and playing his pipe, with his back towards you, is a pure specimen of the poetic. He studied the ancient Romans so much, that he became Roman in his faces, drapery, and figures; and in his naked forms, the common model is too apparent. His finest works are in England; but though distinguished for expression, there is always an antique heartlessness, as if copied from the masks of an ancient theatre.

Bourdon's Return of the Ark is a high proof of his conception; and Le Sueur's St. Bruno is pure in taste, but bad in colour. The Battles of Alexander by Le Brun show the latter to have been of the family of machinists. His colour is bronzed and disagreeable. Le Brun was a court-favourite, and his Greeks, as well as barbarians, have an air of the opera at Versailles. His composition is artificial; and he is not a fit example for youth. The only man who coloured with exquisite feeling was Watteau, whose touch and delicacy of tint may be studied with great profit by any artist.

In a word, it is extraordinary that the French as a nation, have never been right in art. Poussin was the only man who could have set them right, and they persecuted him so, that he settled in Rome. Claude Lorraine can hardly belong to them; and though Louis Philippe is now employing them by hundreds, nothing very eminent has yet proceeded from such encouragement.

Progress of the Germans.

The Germans are taking higher ground than any other nation, and are making rapid advances, particularly at Munich. They have begun again fresco painting; and the liberality of their king has rendered Munich the most flourishing city in Europe for arts and artists; but as Canova said when he was in England, there is very little grand art left in the world. It is extraordinary to reflect on the little original thinking that is to be found. This was more apparent in the Louvre than any where else; and one could not help being amused at seeing the way in which Rubens, who, like Michel Angelo, is supposed to have never looked out of himself, had plundered the old Gothic painters; the Fall of the Damned, by an old German, being the complete basis of the same subject by Rubens.

When incessant demands are made on the genius of a favourite, every aid to thinking is grasped at and improved. Raffaelle did this; so did Rubens; and even Reynolds used to have portfolios brought him to look over at breakfast, and select what would help him, saying, "It will save me the trouble of thinking." This involves a very serious question in art. The utmost merit that can be allowed is that of *skilful adaptation*. "Nihil tetigit quod non ornavit" may be said of all these; and surely a good thought badly done is justifiable food for a superior mind to render it better.

Painting. British school.

We come now to the British School, which, though the last founded in Europe, is inferior to none in variety of power.

There is no doubt that the art[1] would have advanced in Britain side by side with the continental nations, if we had continued Catholics; in fact, we were doing so, when Wickliffe's opposition to the Catholic priests roused up the people to hate and detest every thing connected with their system. Painting of course came under this furious denunciation, and through successive ages went on till the period of the Reformation.

Historical notices of British art.

In Edward the Confessor's time, there were executed basreliefs as good as any thing done at that time in Europe, and by no means deficient in grace, though disproportioned, and unskilful in composition. In one of these there is a king in bed, and leaning upon his hand; which in an improved style might be made a fine thing. In Alfred's reign and before, York and Canterbury were adorned with pictures and tapestry; and in the tenth century, Ethelrida adorned Ely Cathedral with a series of historical pictures in memory of her famous husband Birthwood. As this is recorded, says Strutt, the practice must have existed before; and that it continued to exist and be the fashion down to the Edwards and Henrys, there is good evidence; for in the time of Henry III. mention is made of the immortal Master Walker's painting in Westminster, the no less renowned John Thornton of Coventry, painter there, and the east window of York.[2] In the reign of Henry VIII. there was a chartered society of painters; and in the seventeenth of Elizabeth it was moved in the House by Sir G. Moore, "that a bill to redress certain grievances in painting be let sleep, and be referred to the Lord Mayor, as it concerned a controversy between *painters and plaisterers;*" and Sir Stephen Jones stood up and desired that the Lord Mayor "might not be troubled, and *it seemed to go against the painters.*"

The painters who complained that the plaisterers used their colours, and took the bread out of their mouths, go on to say, that in the nineteenth of Edward IV., that is in 1480, there were orders issued "for the use of *oil* and *size*," and that the "painters' only mixture was *oil* and *size*, which the plaisterers do now usurp and intrude upon." In their petition they observe with the greatest simplicity: "Workmanship and skill is the gift of God, and not one in ten proveth a workman, and that those who cannot attain excellence must live by the baser part of the science." They add that "painting on cloth is *decayed;* that this art is a curious art, and requireth a good eye, and a stedfast hand, which the infirmity of age decayeth, and then *painters go a-begging;*" and then they conclude the petition to the House by this remarkable passage: "*These walls thus curiously painted in former ages the images so perfectly done, do witness our forefathers' care in cherishing this art of painting.*" "This bill," said Sir Stephen Jones, "is very reasonable and fit to pass," and so it did.[3] Painting.

The above extract, proves that in Elizabeth's reign the historical attempts were alluded to, *as belonging to former ages*, viz. from the tenth century downwards; that the House of Commons praised the wisdom of those times in cherishing painting; and that this wisdom the Reformation had obviously discarded.

In 1538, Henry issued an order against the use of pictures and statues to impose on the people; yet pictures are called "bokes for unlearned people." In 1542, in his letter to Cranmer, the king tries to restrain the destruction of pictures; but it was too late. In the reign of Edward VI. the Duke of Somerset fined and imprisoned all those who possessed pictures of religious subjects. To such excess had the fury of the people been excited, that the recorder of Salisbury, Mr. Henry Sherfield, was fined L.500, and imprisoned in the Fleet for not breaking a painted window in Salisbury Cathedral. Walpole says that one Bleese was employed at 2s. 6d. a-day to break windows at Croydon; and in Charles I.'s reign it was ordered,[4] that all pictures having the second person of the Trinity should be burnt, and that all pictures having the Virgin should share the same fate. Cromwell stopped this barbarity, and it was owing to the self-will of this extraordinary man that the Cartoons of Raffaelle were bought in for L.300, at the sale of Charles's effects.

Thus it is clear the art was stopped by the Reformation. In St. Stephen's Chapel, before the alterations made some years since, there were figures painted on the walls, as excellent as any figures in the Campo Santo, and perhaps executed about the same period. In Elizabeth's reign, as we have seen, historical art is referred to with sorrow in the House, as a thing past but which had existed; and in the same reign, says Hillier, "men induced by nature," to pursue high art, "have been made poorer, like the most *rare English drawers of story works.*" Now, Hillier would not have said this, if it had not been true that the drawers of *story works* were principally *natives.*

In Henry VII.'s time, Torrigiano, the same youth who had felled Michel Angelo to the ground in the gardens of Lorenzo and shattered his nose, was in England, and executed important works. In the time of Henry VIII., commissions for high art being over, Holbein devoted himself to court portrait-painting, though in the city he painted some large pictures. Rubens' and Vandyke's visit excited Dobson, a capital painter of a head; but although Oliver was distinguished as a miniature painter, and although there are designs at Oxford, by English painters, no one genius seemed to arise till after Lely and Kneller had succeeded Vandyke. Cooper was the first English painter employed in foreign courts as a miniature painter. Thornhill, a man of talent,

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[1] It is a curious fact, that the art seems to have been in an advanced state in England, while it is doubtful whether there was a painter in Florence in 1236. In 1250 the authorities in Florence sent for some Greeks because there was no painter; yet at that period in England, and long before, historical painting seemed quite the fashion amongst the upper classes. All the king's rooms, as well as his chapel, were painted. In the 25th of Edward III. in the rolls of the Exchequer, 26th September 1351, there is a charge to "William of Padryngton, for making twenty angels to stand in the tabernacles by task-work, at 6s. 8d. for each image, L.6, 13s. 4d." In 1530, were begun the beautiful pictures and designs in St. Stephen's Chapel; and it is curious to see, in all the accounts, the continual allusions to oil-painting. The artists employed must certainly have been men of distinguished talent, who had the power of ordering inferior artists to assist them. The most celebrated of their number appears to have been Hugh de St. Alban's, who was appointed by the king as his principal painter. The following document, dated 18th March, 1350, contains his appointment. "The king to all and singular, the sheriffs, mayors, bailiffs, officers, and his other lieges, as well within liberties as without, to whom be greeting, Know ye, that we have appointed our beloved Hugh de St. Alban's, master of the painters assigned for the works to be executed in our chapel, at our palace at Westminster, to take and choose as many painters and other workmen as may be required for performing those works, in any places where it may seem expedient, either within liberties or without, in the counties of Kent, Middlesex, Essex, Surrey, and Sussex, and to cause those workmen to come to our palace aforesaid, there to remain in our service, at our wages, as long as it may be necessary. And therefore we command you to be counselling and assisting this Hugh, and completing what has been stated, as often and in such manner as the said Hugh may require." (See Britton's *West. Pal.* p. 170.) The illustrious Hugh seems to have been a designer; for in the books, (25 Edward III. April 30,) is the following entry, "to H. de St. Albans, ordering or *designing* the drawings for the painters, one day, 1s."

[2] See Carter's *Etchings.*

[3] See Sir W. Monson's *Account of the Acts of Elizabeth*, 1632, British Museum.

[4] See Journals of the House, 23d July 1645.

Painting. and a member of the House, forms the link between one race and another; and then sprung up Hogarth, Gainsborough, Wilson, West, and Barry. As usual, when Reynolds and Hogarth had for ever rescued Britain from all doubt as to her genius, without an academy of any description, a royal academy was founded to produce more genius, just as had been done all over Europe; and no man equal to Reynolds and Hogarth has since appeared.[1] After the academy was founded at Milan by Leonardo, no genius like his appeared. After that of St. Luke was founded at Rome, Raffaelle and all being dead, no one came forth. After an academy had been founded at Parma, Corregio being gone, nobody appeared. After a national academy was founded at Venice, and royally endowed, genius fled. The same thing happened in Ferrara, Modena, Florence, and Naples; and also in France, Spain, and England. Need further evidence be sought of the uselessness of such institutions?

The Academy. In 1711, there existed a school, of which Kneller was the head, whilst Vertue the engraver drew in it. After 1724, Sir James Thornhill opened a school in his own home Covent Garden, and so did the Duke of Richmond at Whitehall Privy Gardens. Sir James proposed to Lord Halifax to found a royal academy, but without success. At Sir James' death, the school was broken up, and the artists were again left without instruction; when, for the purpose of studying the living model, they hired a room in Greyhound Court, Arundel Street, and Michael Moses was the conductor of it. Here they were visited by Hogarth, who was so well pleased, that a union of the whole body took place, and they removed to Peter's Court, St. Martin's Lane. The number of members amounted to a hundred and forty-one, each paying an annual subscription. There was at the time a great deal of happy fellowship amongst the artists. Reynolds, who was a member, with Hogarth and others, adorned the Foundling Hospital; and the public were so interested, that the society thought they might venture on a charter, which was obtained, and there was established by law a government of twenty-four directors, annually elected, including the president, by the whole body and out of it. An united exhibition having begun, (the constant source of irritation, for every man cannot have his works in the best places,) squabbles arose; and the directors finding the benefit of being able to hang their own works and those of their friends in the best situations, intrigued to keep their places another year. This was foolishly granted; and every subsequent year finding themselves becoming a match for the constituency, they kept their places for eight years, in defiance of law; so that at last it was found that the men elected to preserve order and law, had been the grossest violators of both. With the feelings of independent freemen, the constituencies resolved to endure this no longer; when, to prevent collision, it was agreed to refer the point to the Attorney-General, De Grey, both parties pledging themselves to abide by his decision. De Grey gave it against the directors, and these honourable men then refused to keep their word. The constituency met, and violently expelled sixteen of them; but before resigning, these gentlemen met secretly, and fearing exposure, tore out and destroyed the minutes from the 19th November 1764, to the 11th March 1765, and from the 17th of June 1765, to the 21st of March 1766. They then went to the king, George III., whom they persuaded that the chartered body was republican; and that there was no hope unless a royal academy was founded, with the number of members and voters limited to forty. The king, without inquiry, foolishly yielded to their cunning suggestions, and founded an academy with forty members; the other eight directors resigned directly, and the whole twenty-four were made R.A's. Thus by this limited number were framed the present exclusive law and constitution, and all the obnoxious regulations passed, which had been checked by the sense of a constituency; and thus the art of England received a blow more fatal than at the Reformation. The weakness of the nation has been gratified to an excess by this interested assembly, to the ruin of their taste and judgment; high art has gone back, and is going back further every year, by the struggles of these men to keep up their monopoly, in defiance of the increasing intelligence of the people, which they fear, and which will yet be their utter destruction. In this affair Reynolds behaved with great meanness. He promised to stand by the constituency; yielded at the offer of a knighthood; was afterwards justly punished, by being compelled to resign; and foolishly complained of ingratitude which he had deserved.

In order that the state of art in Great Britain may be rightly understood, this authentic detail, taken from pamphlets published at the time, especially that of Sir Robert Strange,[2] has been thought necessary; and it will not appear tedious, if it be considered that, for the sake of the art of our own country, it is but just that particulars should be ascertained. The effect of the academy has been pernicious. Imitating the example, all the eminent provincial towns have established exhibitions instead of schools; and every year the annual exhibition in the metropolis is repeated in the provinces, with but little addition to that which proved unsaleable in the London show. Hogarth opposed such a conclusion, and from the beginning predicted its effect, which has happened to the very letter; and when Reynolds began to perceive the truth, he acknowledged his error, and said to Sir George Beaumont, that "a party was gaining ground which would ruin the art."[3] If the detail of every other academy in Europe could be thus laid open, the same intrigues, the same despotism, the same injustice, and the same want of principle would be found at the bottom; and Europe would no longer wonder that academies never have produced a Raffaelle.

Reynolds. The honest and straight forward constituency being thus left as it were unprotected by the king, it was soon deserted by the nobility and the public, and shortly escaped notice altogether; though such a man as Hogarth had improved his knowledge by drawing in its schools. The literary splendour with which Reynolds was surrounded, gave a glory to the Academy which it has not yet lost; and the genius of Reynolds spread a halo around it, which the artists still fancy they see, though it vanished the moment he expired. Reynolds was really a great artist; gorgeous in tone and colour, unimpeachable in composition, deep in light and shadow, beautiful in character, and the purest painter of children and women that ever lived in the art, Greek or Italian. His ignorance belonged to the period; his beauties were entirely his own; and though he overrated Michel Angelo, and has done injury to taste, by his sincere conviction that he was right, yet had he lived to see the Theseus or Ilyssus, he would have been equally candid in saying he was in error. Lord Heathfield is a portrait that need not fear any work of Titian's for men, and Mrs. Parker, a tender, sweet picture of a woman, was never equalled in sentiment or delicacy by any work of the Venetian and Roman schools. Where were children ever so completely hit as in the Infant Academy? who surpassed the propriety of his back-grounds as well as their splendour? His eye, or rather his organ for colour, was exquisite; nor is there in the whole of his works a heated and offensive tint. He did not combine essential detail and breadth so beautifully as

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[1] Wilkie was not produced at an academy, but at Graham's school, Edinburgh. Now this school is an academy with all its pride, and nobody will come of it.

[2] See Sir Robert Strange's pamphlet, and another published in the year 1771, by Dixwell, St. Martin's Lane, entitled "On the Conduct of the Royal Academicians," in the British Museum.

[3] This was told the author by Sir George; and has since been confirmed by his pamphlet, "Concise Vindication," &c. in British Museum.

Painting. Titian; but place one of his finest portraits by the side of any picture of Titian's, see them at the proper distance, and Reynolds would keep his station. Here, however, the praise must stop. Reynolds could have no more painted Pietro Martyre than he could have revived the martyr after he was dead. He was not so great a man as Titian, because he did not like him remedy his ignorance, when he found it out at a much earlier age. He was always talking of what he would do if he began the world again. Sir Joshua loved society; he was the deity of his coterie; he liked a glass of wine and a game at whist; and he never lost his temper because he was successful in the world, but the first time he was thwarted he got in a passion. Reynolds was a great genius in painting, but not a great man. He raised English art from the dust, and gave English artists an *à-plomb* in society which they never had before, and he first reduced the art to something like system by his discourses; but not having moral courage to resist the formation of an academy, which *he* could have done by his influence and his genius, he compromised the art, and was indirectly the means of throwing it off its balance, which it will yet take half a century more to remedy, as Hogarth predicted.

Hogarth. As an inventor, Hogarth is by far the greatest of the British school; although in aim and object, colour, surface, and all the requisites of a great painter, infinitely below Reynolds. It would be useless to detail the perfections of a man so admired all over the earth, and who will only cease to be a delight with its existence. It is astonishing how hereditary is the hatred of academies. The painters in revenge for Hogarth's opposition, swore that he was no painter, and swear so to this hour. The absurdity of this criticism can be proved by the Marriage à la Mode, whilst the picture of the husband and wife after a rout, is as beautifully touched as any in that class of art can be. He has not the clearness of Teniers, nor the sharpness of Wilkie; his touch is blunt, and his colour deficient in richness; but you feel not the want whilst looking at him; and although his expression is often caricature, yet in the above picture it is perfection. Hogarth unfortunately believed himself infallible; but his wretched beauty of Drury Lane for Pharaoh's daughter at the Foundling, his miserable Sigismunda, and his Paul before Felix, we hope convinced him of his forte. If he was *serious* in these pictures, which we very much doubt, he deserved a strait waistcoat and a low diet as the only treatment for his hallucination.

Gainsborough. Gainsborough was another painter of great genius in portrait and landscape; but Wilson was a greater. His touch and feeling were comprehensive, though too abstracted for the vulgar, who always like polish and to put up their fingers. He used to say to Sir George Beaumont, "When somebody is dead somebody's pictures will sell better." From neglect he got into foolish habits of drinking and died librarian to the academy. A miserable dauber called Lambert was the fashion, and his character as a landscape painter was hit by poor Wilson. He said "his trees and foliage were eggs and spinach, and nothing more;" yet Lambert got hundreds when Wilson could hardly get shillings. But where are now the immortal Lambert's works? Making fire-screens for garrets, whilst "*somebody's* pictures" adorn the houses of the great. Gainsborough was a great portrait painter and ran Reynolds hard. West's Wolf and La Hogue are the triumphs of his talent; but his great sacred subjects are inferior works. The writer of this observed to Canova in England, "Au moins, il compose bien." "Monsieur," replied the Italian, "il ne compose pas; il met des figures en groupe." He was a skilful machinist; and though there are bits of colour in his small works, rich and harmonious, his portraits are detestable, his handling unfeeling, his drawing meagre and common. He was deeply versed in nothing, though possessing great acquired knowledge of his art without being an educated man. With respect to his being the greatest man since the Caracci, with Rembrandt, Rubens, Vandyke, and Dominichino, Guido, and Guercino since, or a little after, the idea is ridiculous and absurd. The king hated Reynolds on account of his devotion to Burke and Fox, and puffed West from sheer irritability. The king said to Hopner, "Why does Reynold paint his trees *red* and *yellow?* who ever saw trees that colour?" Hopner, who said what he pleased, replied, "Then your majesty never saw trees in autumn." Painting.

Romney. Romney, a second-rate man, had great patronage, whilst Barry, a man of great grasp of mind, had none whatever. Barry joined the Academy to oblige Reynolds, against his own convictions; was soon at issue with its selfish monopoly; opposed it; urged the propriety of devoting a portion of its funds to establish a school of colour; exasperated the intriguers by his fearless attacks; and was expelled of course as an obnoxious man, the king having been persuaded to sanction it, under the deadly hint that Barry was a radical. Barry was the protégé of Burke, and his Adelphi pictures, shewing the progress of society, though deficient in drawing, colour, and delicacy of touch, were the first work in England on the comprehensive principle of the ancients. Having neglected Burke's repeated entreaties to dissect, he suffered the consequence. His forms at the Adelphi are such as can be got by general drawings from the antique, but there is no refined knowledge of construction in them.

Barry. As a man of genius, however, Barry is not to be compared to Henry Fuzeli, the friend of Reynolds and Lavater, and one of the most distinguished and accomplished men of his time. Fuzeli was undoubtedly the greatest genius of that day. His Milton gallery shewed a range of imagination equal to the poet's; his Satan bridging Chaos, his Uriel watching Satan, his Shepherd's Dream, his Fairies from Shakespeare, and his Ghost in Hamlet, announce him as having conceived, like Theon, φαντασιας, and as being the greatest inventor in art since Julio Romano. But in the modes of conveying his thoughts by form, colour, light, and shadow, and above all, nature, he was a monster in design; his women are all strumpets, and his men all banditti, with the action of galvanized frogs, the dress of montebanks, and the hue of pestilential putridity. No man had the power like Fuzeli of rousing the dormant spirit of youth; and there issued from his inspirations a nucleus of painters, who have been the firmest supporters of the British school.

Fuzeli. But Fuzeli, as a painter, must be a warning to all. Had he taken the trouble to convey his thoughts like the great masters, his pictures would have risen as time advanced; yet as time advances, his pictures, from having no hold on our feelings like the simplicity of nature, must sink. His conceptions however poetical, are not enough to satisfy the mind in an art, the elements of which are laid in lovely nature; and great as his genius was in fancy and conception, inventor as he was in art of fairies and ghosts, he will never be an object to imitate, but always to avoid by young men, who are more likely to lay hold of his defects than his beauties. The finest conception of a ghost that was ever painted, was the Ghost in Hamlet on the battlements. There it quivered with martial stride, pointing to a place of meeting with Hamlet; and round its vizored head was a halo of light that looked sulphureous, and made one feel as if one actually smelt hell, burning, cindery, and suffocating. The dim moon glittered behind; the sea roared in the distance, as if agitated by the presence of a supernatural spirit; and the ghost looked at Hamlet, with eyes that glared like the light in the eyes of a lion, which is savagely growling over his bloody food. But still it was a German ghost, and not the ghost of Shakespeare. There was nothing in it to touch human sympathies combined with the infernal; there was nothing at all of "his sable, silvered beard," or his countenance more "in sorrow than in anger;" it was a fierce, demoniacal, armed fiend reeking from hell, who had not

Painting. yet expiated "the crimes done in his days of nature," to qualify him for heaven. His next finest works were the two fairy pictures in the Shakespeare gallery, some diving into harebells, some sailing in Bottom's shoe; but beautiful as they were, indeed the only fairies ever painted, still your heart longed for nature in colour, form, action, and expression. Such an union had the Greeks, and no art in the world will be perfect until it appears again. These pictures are evidences of the highest conception of the fanciful and supernatural. His Lazar House is an evidence of his power of pathos; his Uriel and Satan of the poetical; his Puck putting on a girdle, of the humorous and mischievous. But when Fuzeli attempted the domestic, as in the illustrations of Cowper, his total want of nature stares one in the face, like the eyes of his own ghosts. Never were the consequences of disdaining the daily life before your eyes, or of affecting to be above it, so fatally developed as in this series of design; though in comparing with him another eminent artist, namely, Stothard, who, in sweetness and innocence, was his decided superior, Fuzeli surpassed him in elevation and reach of mind. In the pictures of Stothard, who painted equally well without life before him, there is not the same extravagance, yet there is almost equal want of nature in another way. Flaxman, Stothard, and Fuzeli, are the three legitimate designers of our school, and yet not one of them was perfect master of the figure.

Flaxman. Flaxman's designs from the Iliad and the Greek tragedies are his finest works; and when first they appeared in Italy, they were denied to be the invention of an Englishman, as it was supposed to be impossible that any Englishman could have an imagination. But yet of some of these designs it really may be said, "Il n'y a qu'un pas du sublime au ridicule." It is extremely difficult to say whether they are in the highest degree sublime or extremely absurd. In all attempts to express the passions, you will perceive extravagance; but in comparing him with Canova, in this part of the art, Canova must yield the palm as much as Flaxman was inferior in the perfection of working up a single and beautiful figure. Though this eminent man talks pompously of Greek form and anatomical knowledge, he in reality knew very little of either; and though there is a great deal of useful matter of fact in his lectures, yet on the whole they display a wretched poverty of thinking. His book of Anatomy for students is not deep enough on the separation of muscle, bone, and tendon, and can help a young man a very little way to correct notions. The value of Fuzeli's and Opie's lectures in comparison with Flaxman's or Barry's is evident; and the superiority of Reynolds to all, except Fuzeli in his lecture on Greek art, needs not to be dwelt on.

Stothard. Stothard, as an inventor in composition, was equal to all, but as a painter, certainly inferior to all. In fact he could not paint; he had no identity of imitation; he did not and could not tell a story by human passions; and his style of design showed great ignorance of the constituent parts of the figure. But there was a beautiful and angelic spirit that breathed on every thing he did. He seems in early life to have dreamed of an angel, and to have passed the remainder of his days in trying to endow every figure he designed, with something of the sweetness that he had seen in his sleep. Peace to his mild and tender spirit. It was impossible to be in Stothard's painting-room for ten minutes without being influenced by his angelic mind. He seemed to us always as if he had been born in the wrong planet. He had a son whose etchings from our ancient tombs are an honour to the country. He fell from a great height, in pursuing his designs from some tomb in a country church, and was killed. This ill-fated artist was in every respect worthy of his father. Painting.

West. Never were there four men so essentially different as West, Fuzeli, Flaxman, and Stothard. Fuzeli was undoubtedly the man of the largest capacity and the most acquired knowledge; West was an eminent artist in the second rank; Flaxman and Stothard were purer designers than either; Barry and Reynolds were before all the others. In Barry's Adelphi there is a grasp of mind, as Johnson said; yet as a painter he was inferior to all. Though Fuzeli had more imagination and conception than Reynolds, though West put things together with more facility, and Flaxman and Stothard did what Reynolds could not do; yet as a sound, great, and practical artist, in which all the others were deficient, Reynold's must be considered the head of the British school as a painter and handler of his brush.

Opie, Northcote, Wilkie. Opie must not be omitted, nor Northcote his imitator and contemporary, both of them men of talent. Opie, a man of great and powerful genius, issued from Cornwall at once on the town. Northcote was six years with Reynolds; and his Arthur and Hubert, and Children in the Tower, are fair specimens of his talents. He was a malicious man, and tried to injure his greatest protector, Reynolds, and Dr. Mudge who introduced him, by allowing Hazlitt to print his (Northcote's) Conversations. There never was a deeper scheme for malignant defamation. Northcote always said that *he* did not print them, and Hazlitt that *he* did not talk them; and each vented his spite on a mutual friend, and shifted the blame to the other. Reynolds was succeeded by West, and the art sunk to the lowest depth, containing only Sir Joshua's humble imitators, when a genius broke forth, David Wilkie, who rendered our domestic school, the first in Europe; and the feeling for art has been rapidly advancing amongst the people ever since. This many circumstances unite to prove.

Parliamentary inquiry. In consequence of the perpetual complaints from the great body of artists, the government granted a committee in 1836, to examine the cause of the superiority of France in manufacturing design, as well as the condition of high art, and to ascertain if the accusations against the Royal Academy were true or false. Never in the world were the consequences of a monopoly on the perceptions of respectable men so ludicrously developed. The president and body first denied the right of the House of Commons to examine them at all; and when the persuasions of their friends showed them their folly, their appearance before the committee presented a scene never to be forgotten in the history of English painting. On all questions of finance, they proved satisfactorily the honour of their transactions; but on all questions of art more was proved against them than ever had been suspected.[1] The resignation of Reynolds, and the expulsion of Barry; the loss of a million of money to the art on the Waterloo monument, in consequence of their not replying to Lord Castlereagh's committee; their refusal to let the artists also support their exhibition, and have the same opportunities of fitting their works for the public as at the British Gallery; and, to crown all, their rendering the school of design lately established of no avail to the mechanic, by establishing a law, that the study of the figure is not necessary for his education, though it was proved that this study at the Lyons academy for mechanics, was the real cause of their superiority to us; are such indisputable evidence against their protestations of sincerity, that it has rendered the nobility and the nation more than suspicious of the truth of all the accusations which have been made against them.

Scottish art. In Scotland the art is in a promising condition, and the Scottish school in purer taste than the English. Living as

[1] See *Report on Arts and Manufactures*. In this Report the important subjects of Art and Manufacture are both considered; and no one with any pretensions to taste, should be without it.

Painting. the artists do, in the most magnificent city in Europe, surrounded by a country pregnant with historical recollections, and guided by their own shrewd understandings, the school in Edinburgh will, before many years, take a very high rank in the art. But there is some cause to apprehend that it will be checked at its most critical period, from the usual cause, the foundation of the old curse of Europe, an academy. After having produced Runciman, Raeburn, Wilkie, and the other eminent men Scotland can boast of in art, they have been persuaded to found conventional distinctions, in favour of a select few; and, as elsewhere, the result will be the same. No Wilkie, no Runciman, no Raeburn will come from it; for the best men they now possess were eminent before it was thought of. The art has no business with any aristocracy of talent. Conventional distinctions, which are not hereditary, are laughable and absurd; and distinctions which are, ought to be reserved for high descent, heroic actions, landed property, or vast political genius. Such an aristocracy produces heart-burnings and injustice; for it places power in the hands of men, who are not amenable to justice for tyranny, and who cannot be reached by law, for calumny or insinuation. "Of all hatreds," said the *Edinburgh Review*, "there are none to equal the hatreds weak men in power bear to the man of genius without it." It is a curious evidence of the sagacity of the Scotch, that whilst the English portrait painters, since the death of Reynolds, were all placing kings and queens on their toes, from sheer ignorance of perspective, Raeburn, Wilkie, and Gordon have never made that mistake.

In a word, it is our decided and unprejudiced conviction, that the genius of the British people, will never have fair play or be soundly advanced, till the Royal Academy is removed, or effectually remodelled; and this will be effected either by the positive interference of the queen or the government, or by the rapidly increasing knowledge of the people. If the capital and the provinces were freed from the predominence of those men; if the honours were abolished and the constituencies restored; if the whole national galleries were turned into a great school, with branch schools in the great towns; if the Cartoons were removed to London for the occasional sight of the people, as they might be inclined to drop in; and if a Native Gallery were arranged for the best productions to be purchased as they appeared, and the House of Lords adorned with a series of grand works referring to the British constitution; then would the government do a real good to taste, refined pleasures, and design for manufactures, such as would entitle them to the everlasting gratitude of the nation.

On the other hand, if all the ancient boroughs of the land have been obliged to bend to the call for reform; if the crown itself has been obliged to yield up the old House of Commons; if the salaries of our great officers of state have been cut down without complaint; if pensions bestowed equally for merit or for vice, are to be rigorously sifted; if the queen herself has been obliged to permit her expenditure to be questioned; are a set of men without a lease of their House, or charter for their existence, without any one legal claim to be considered as a constitutional body—are *they* alone to brave the Commons and the Lords, are *they* alone to defy and deny reformation, taking their stand upon their utter insignificance? If so, it will be an anomaly in the character of the British Legislature, which, in after times, will only be remembered as a proof of imbecility and folly, if not of something still worse than either.

General deductions. We have now gone through the great leading schools of Italy, France, Germany, Flanders, Holland, Spain, and Britain, and we have taken those names only, which may be considered as leading an epoch; so that, in such a system, many eminent men must of necessity have been omitted. From the Petersburg, Copenhagen, Berlin, or Stockholm academies, no great genius except Thorwaldsen has yet appeared.

Was Italian art equal to Greek art? Certainly not. In the finest Italian there is a want of beauty in form and face, which Greek art could only supply. Poussin said, that Raffaelle was an angel in comparison with the moderns, but in comparison with the ancients he was an ass. Though this is vulgar, it is in our opinion true. The ancients combined the Venetian and Roman schools; they considered form, colour, light and shadow, surface, expression, and execution, as all equally component parts of imitation, and all necessary to perfect that imitation which was to be employed as an instrument to convey thought. They combined the drawing and the colouring of the two great Italian schools; as these illustrious schools tried to do when they found out their error, in pursuing one at the expense of the other. Painting.

Reynolds, from the defective practice of each school, laid it down that colour was incompatible with high art; and he also laid it down that the ancients could not be great painters in a *whole*, though they might be in a *solo*, from the pictures on the walls of Pompeii. We do not wonder at any man so concluding before the Elgin marbles arrived; but we do marvel at Reynolds taking the works in the private rooms of a provincial Roman city as justifiable grounds on which to estimate the extent of genius in Greek art at its finest period, five hundred years before. But after all, what are the pictures of Pompeii? Very probably the designs in Pompeii would rank about as high in ancient art, as the designs of our paper-stainers in Bond Street would in British art. The pictures at Pompeii are no more criteria of what the art of Apelles and Polygnotus really was, than any sculpture dug up there would be a criterion of what the art of Phidias was. Reynolds undervalues contemporary praise; but Quintilian, Cicero, Horace, Juvenal, Strabo, Polybius, and Pausanias, Valerius Maximus, Ælian, and Pliny, were not contemporary; and, therefore, the praises of Aristotle or of Plato who were, justify the enthusiasm of those who were not.

Since the works of Phidias arrived in England, we have positive evidence that the Greeks knew the great principles of composition and grouping, as applied to painting; because the metopes are instances of arrangement of line, that will do exactly in a picture, if the Laocoon had not shown it before. Having now seen the Elgin marbles, which the Greeks estimated as their finest work, and having found all the enthusiasm of the ancients more than borne out, have we not a justifiable ground to argue from what we *do* see in one art, that what we do *not* see in another was equally excellent? Will any man, after seeing the Theseus and Ilyssus, doubt that the ivory Minerva and Olympian Jupiter were equally, if not more beautiful? Why should the ancient critics have faith placed in all their decisions except those on painting? Why should they lose their perspicacity of understanding only when they talked of this art? After Aristotle and Plato had admired the Minerva inside the Parthenon and the sculpture outside, they might admire the pictures; and nobody will deny them the power of making comparisons. Had the Elgin marbles and the old antique never been seen, would not the same sophistry have been put forth to question the merit of their sculpture as well as to deny that of their painting? "Nothing can be more perfect than Phidias," says Cicero. "You cannot praise him enough," exclaims Pliny. "He made gods better than men," says Quintilian. "He was skilful in beauty," says Plato. You believe all this, because you cannot contradict it; but the moment Quintilian says, "Zeuxis discovered light and shade; Parrhasius was exquisite for subtlety of line; Apelles for grace; Theon for poetical conceptions, (φαντασιας); Pamphilus for mathematical principle; Polygnotus for simplicity of epic arrangement in colour and form; Protogenes for finish;"—when Pliny commends Aristides for expression, and Amphion for composition, and speaks of the grand assemblage of the gods by Zeuxis, as well as the single figures of Apelles, Reynolds Painting.

Painting. replies, "Admiration often proceeds from ignorance of higher excellence, I will not believe contemporaneous praise." We answer, that admiration oftener proceeds from knowledge of superior excellence; that the most enthusiastic admirers of Greek painting were not contemporary; and that Reynolds' conclusions against Greek art are founded upon data which are altogether erroneous.

Taking the Elgin marbles as a standard, we cannot but suppose that the finest great works of Greek art had the finest drawing, the most wonderful knowledge of form, the finest grouping, and the finest expression. To this may be added, colour from Pliny, light and shadow from Quintilian; perspective from Vitruvius; fore-shortening, dwelling on the leading points, like Vandyke, and touching off the inferior parts from Plutarch; and, what was never suspected, execution with the brush from Horace, on the leading principles of the Venetians. The French used to affirm, that David's principle was the same as that of the Greeks, namely, obtruding on the attention all the superior parts, and neglecting the inferior ones. In Plutarch's life of Alexander, at the very beginning, he describes to his readers his plan of writing his lives, and concludes with this extraordinary passage: "Like painters that paint portraits, who dwell on the face, caring little about the remaining parts."[1] His meaning is, that he would, like painters, dwell upon the leading points in the history of great men and lightly touch off the inferior parts. Could he have made such an allusion for the general reader, if this had not been the practice of the great Greek painters? Again, Horace says in the art of poetry,

> Ut pictura poesis erit; quæ si *propius* stes,
> Te capiat magis; quædam si *longius* abstes.

That is, some pictures are painted for a close, others for a distant inspection. The former, of course, are wrought up; but in the latter, the leading points are seized by a touch, leaving the atmosphere to unite. As to mere handling of the brush, this is conclusive, and shows that it was done on the same system as by Titian, Tintoretto, and Velasquez. Reynolds has quoted Pliny's description of glazing, that is, spreading a thin transparent tint over the crude colours to bring them into harmony, which was the practice of the Venetians. Another passage completes the conviction: "Adjectus est *splendor*, alius hic quam lumen, quem quia inter hoc et umbram esset, appellaverunt *tonon*." (Lib. xxxv. c. 5.) "Now was added *splendor*, a different thing from light, and which splendor, because it was between light and dark, was called *tone*." To the mind of an artist this is exquisite in distinction; first, the colours on the tablet were fresh, unmixed, and raw; then was spread over a transparent glaze to take off the crudeness; then this crudeness being reduced, it was called *splendor*, glowing, rich, and deep, but different from *light*, which is cold and white; and this splendor the Greeks called *tone*, as both the Venetians and the British denominate it. But the circumstance of tone being the characteristic of any school, is proof of an age for colour.

As to their perspective, let any man consult Vitruvius, (lib. vii.). Agatharcus composed a treatise on the subject; and from this hint, Democritus and Anaxagoras wrote on perspective, explaining in what manner we should, in appearances agreeable to nature, from a *central point* make the lines to correspond with the eye and the direction of the visual rays, and render the scene a true representation of buildings, that those objects which are drawn on a perpendicular plane, may appear some retiring from the eye, and some advancing towards it. From a passage in Plato, it is clear, that the Greeks carried the illusions of theatrical perspective to a much greater extent than, in consequence of some bad landscape discovered in Herculanum, has been supposed."[2] That they foreshortened is clear, from Pliny's description of a bull coming out of a picture frontways. Painting.

The inferences to be drawn from all this, are, first, from Plutarch and Horace, that the Greeks had execution like Titian and Vandyke; secondly, from Pliny, that they must have had fine colour, (lib. xxxv.); thirdly, from Quintilian, that the principles of light and shadow were understood, (lib. xii.); fourthly, from Vitruvius, (lib. vii.), that they had sufficient perspective to make objects recede and advance; and fifthly, from the Elgin marbles, executed by and in the school of Phidias, who was first a painter, that they had expression, form, and composition. If the three most important can be proved, as they can, and colour, light and shadow, and execution, more than inferred; what right has an eminent English portrait-painter, grossly deficient as a painter of high art, to assert, that they could not be great in extensive compositions, because the painted walls of a provincial city gave no evidence of such excellence in their private houses? forgetting that these were executed five hundred years after the eras of Greek perfection, when Greece was a Roman province, when her cities had been sacked, and her art was talked of as a wonder that had passed away.

Conclusion. The principle laid down for high art has been, that the lower addresses the eye and the higher the mind, and that the union of the two was incompatible; whereas, the true principle surely is, that both styles address the mind through the eye, but in different ways; the lower walk making the imitation of the actual substance the great object of pleasure only; and the higher walk making imitation the means of conveying a beautiful thought, a fine expression, or a grand form with greater power. The imitation though more abstracted must not be less real or effective. Sir Joshua Reynolds affirmed, that the look of truth which fine colour, light and shadow, and reality gave, distracted the eye from the poetry of the conception or the depth of the expression. But it may be maintained, that in an art, the elements of which are laid in imitation, the beauty of an expression, the grace of a motion, and the sublimity of a conception, will be *increased* in proportion to the look of *reality* in the objects; and the practice of all the great Greek painters, and of Raffaelle and Titian in their latter works, (the Transfiguration, and Pietro Martyre), proves that they had come to the same conclusions. Yet Reynolds, with his usual sagacious policy, appears to waver lest he should be wrong. "There is no reason," says he, "why the great painters might not have availed themselves with caution and selection of many excellencies in the Venetian, Flemish, and Dutch schools; there are some not in contradiction to any style, a happy disposition of light and shade, breadth in masses of colour, the union of these with their grounds, and the harmony arising from a due mixture of hot and cold tints, with many other excellencies which would surely not counteract the grand style." And then he concludes that "a subdued attention to these excellencies must be added to complete a perfect painter." This is all that is contended for. So far from these excellencies being incompatible with grandeur of style, they are essential to it, they are the elements and the basis of it, they cannot be left out, or if they are, the style is deficient, absurd, and not founded in nature. There is not the least doubt that the Greek painters considered the power of imitating natural objects by colour, and light and shadow, as necessary and requisite in preparatory study as drawing or composition; and the greatest painters in the grand style in ancient Greece, were

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[1] —— ὡσπερ οὐν ὁι ζωγραφοι τας ὁμοιότητας ἀπο του προσωπου, ἀναλαμβανουσιν, ἐλαχιστα των λοιπῶν μερων φροντιζοντες.
ΑΛΕΞΑΝΔΡΟΣ.

[2] *Theatre of the Greeks*, p. 262, 3d edition, Cambridge.

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just as capable of imitating still life as the possessors of it now.

It may, therefore, be fairly deduced, that the Greeks possessed all parts of the art, and none particularly to the exclusion of others; that, therefore, all parts of the art, in due subordination, may be considered as essential to an artist of the highest walk, as also in the more humble department; and that the system of Reynolds, which excludes identity and power of reality from judicious imitation of the objects painted, combining colour and light and shadow, as well as expression and form, is *false*, and should be exploded from all systems where art is considered as a matter of importance to the dignity or glory of a nation.

(Q. Q. Q. Q.)

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HOUSE-PAINTING.—In a country with a climate like that of Great Britain, house-painting is an art of much importance, as being conducive to the durability and comfort of our dwelling-houses; and in every country it is an art, which, though somewhat mechanical, may be made to approximate to those of a higher and more intellectual nature. The house-painter, therefore, ought to make himself thoroughly acquainted, not only with the mechanical department of his business, but likewise with the rules by which high art is governed, especially those of harmonious colouring. By such means he will, in the first place, understand the best methods of rendering his work capable of resisting for many years the effects of a changeable climate and humid atmosphere; and, secondly, he will be enabled to render even his plainest work pleasing to the eye of the intelligent and tasteful. It is further necessary that he should make himself acquainted with the various styles of ornament, not only in painting, but in architecture, and also with such of the ornamental works of the great masters of antiquity as are still in existence.

For nearly a century house-painting in this country was in the most degraded state; so much so, that when any thing beyond the plainest style of work was required, artists were brought from France to execute it; and specimens of their skill may still be found in many of the mansions of our nobility and gentry. Within these fifteen or twenty years, however, great improvements have been made. The handicraft department has not only become equal, but it is believed, superior to that of any other country, especially in the imitations of the finer kinds of woods and marbles; whilst attention to the scientific part of the art, if it may be so called, is rapidly becoming more general in practice.

We shall, in the first place, give a short account of the plainest branch of house-painting.

It is well known that the ceilings and walls of apartments in dwelling-houses and other buildings of this country are now almost uniformly finished in plaster; and the nature and properties of this composition are also well known. One of these properties is its power of absorbing moisture; consequently, when an apartment is left for any length of time without the benefit of a fire, or heated air supplied by other means, the plaster will continue to absorb a portion of the humidity with which the atmosphere is generally loaded; and this absorption will not only render the room unwholesome, but will tend to impair the durability of the plaster itself. The first object, therefore, in painting a house, is to render the interior walls impervious to this absorption; and for this purpose the house-painter provides various materials.

These are, white lead, ground in refined oil to the consistency of a thick paste, which operation is now performed by machinery on the premises of the original manufacturer, instead of being done by a clumsy hand-mill as formerly in the painter's shop; linseed oil, spirits of turpentine, litharge, sugar of lead, japanners' gold size, ochre, venetian red, lamp black, indian red, Turkey and English umber, terra de Sienna, red lead, Prussian blue, orange lead, chrome yellow, vermillion, lake, and other pigments. But white lead is the material of the greatest importance, as it is the principal ingredient in all ordinary colours used in house-painting; indeed, it generally constitutes nine-tenths of the composition, and consequently forms the main body of the paint. The quality of this article is therefore of the greatest importance, as upon it depends almost entirely the durability of the work; yet it is of all the painter's materials the most difficult to get free of adulteration. There are three qualities of this article manufactured, the prices of which vary, according to that of pig lead, from about 27s. to 40s. per cwt. But this difference in the price of white lead is trivial in comparison with the mode in which it is sometimes adulterated. This is done by the introduction of fine whiting ground in oil, in the same manner as the white lead. The cost of this is about 5s. per cwt., and, as detection is very difficult, the temptation to adulterate is proportionally great. But how much greater must it be to the needy tradesman, who can employ it alone instead of white lead in the two first coats of his work, with scarcely a possibility of his employers knowing any thing of the matter? This in some measure accounts for the great difference that exists in the prices of painters' work. The injury done to paint by the admixture of whiting is, that it not only renders it of a much less compact body, but, causing it to be more easily acted upon by the atmosphere, renders it much more liable to be blanched and destroyed by repeated washings.

Linseed oil being the principal diluent, stands next in importance. It varies but little in quality, and is seldom adulterated; the superiority of one kind over another consisting entirely in its clearness, and being of a moderate age. It is sometimes boiled, which gives it great facility in drying, but renders it so thick and unctuous that it is only fit for out-door work.

Spirits of turpentine, of which a great deal is now used in house-painting, is also rather uniform in quality; but varies greatly in price according to the state of the market. Perhaps the only difference in its quality, consists in the manner in which it is distilled; and it is easy to distinguish what has been properly done by the absence of the resinous matter which is generally to be found in that which has been distilled with less care.

Litharge and sugar of lead are purchased by the painter in a dry state, ground in oil into a paste of a thick consistency, and used to dry and harden paint. They do not vary much in point of quality. Japanners' gold size is a liquid of which there are various qualities, the price being from 10s. to 18s. per gallon. It is used for the same purpose.

Several of the colouring pigments are equally various in quality, and the house-painter, in laying in his stock, can suit it exactly to the rates of prices at which he works; some of them varying from 9d. to 3s. per lb. according to the quality, and others, such as ochre, from 2d. to 1s. per lb. These are the principal materials employed by the house-painter in the plain department of his work; and it will now be necessary to give some account of their application.

To paint plaster properly, five coats are generally requisite; but where it is not of a very absorbent nature, four

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are found to answer. The first is composed of white lead, diluted with linseed oil, to rather a thin consistency, in order that the plaster may be well saturated; and into this is put a small quantity of litharge to insure its drying. In quick plaster, which is the best for painting, the oil in this coat is entirely absorbed, thereby hardening the plaster to the extent of about the eighth of an inch inwards from the surface. When this is found to be the case, the second coat should also be thin that the plaster may be thoroughly saturated; and it will be found necessary after this to give other three coats, making in all five. The second coat will be found to be but partially absorbed, and it is therefore requisite to make the third coat a good deal thicker, and to introduce into it a little spirits of turpentine, and such of the colouring pigments already enumerated, as may bring it somewhat near to the tint of which the apartment is to be finished. The fourth coat should be as thick as it can be well used, and should be diluted with equal parts of oil and spirits of turpentine. The colour of it ought to be several shades darker than that which is intended for the finishing coat, and the drying ingredient, sugar of lead instead of litharge. These coats ought all to be laid on with much care, both as to smoothness and equality, and each lightly rubbed with sand-paper before the application of the other. The finishing or flatting coat, as it is termed from its drying without any gloss, is next applied. It ought, like the others, to be composed of pure white lead, ground as already described, and diluted entirely with spirits of turpentine; and it should appear, when mixed, a few shades lighter than the pattern chosen for the wall, as it darkens in the drying. The drying ingredient should be a small portion of japanners' gold size. This coat must be applied with great care and dispatch, as the spirits of turpentine evaporate very rapidly, and if touched with the brush after that takes place, which is in little more than a minute after its application, an indelible glossy mark will be left on the surface. Nothing has been said of the time that each of the coats will take to dry sufficiently to receive the next; as that depends much on the state of the weather, the quantity of dryer employed, and the atmosphere kept up in the apartment. It may be observed, however, that under any circumstances the first coat ought to stand a few days before the application of the second; the second a little longer before the application of the third; and the third, unless in four coat work, should have still longer time to harden. But the coat immediately before the flatting or finishing coat ought not to stand above two days, as much of the beauty and solidity of the work will depend on the latter dying into and uniting with the former.

The description of this process might be sufficient to convince every one, that there could be no better mode of rendering the plaster of which the walls of our apartments are composed, impervious to the effects of our changeable and humid climate. In the first place, it hardens the surface, and then forms a compact, and smooth incrustation, upon which the dampness of the atmosphere can only condense when any sudden change takes place in the temperature. This is often exemplified in staircases, where the wall gets so low in temperature during a continuance of cold weather, that when a change takes place the condensation is so great, that the water runs in streams upon the steps. How then, we may ask, can any one employ paper-hanging, or any other absorbent mode of finishing in such apartments? It ought to be well known, that in such cases the moisture instead of being condensed and rendered easily removable, is absorbed and gradually given out in connexion with the natural effluvia of glue, rotten paste, and other noxious materials.

In many cases it has been found that this substantial style of painting is too heavy in its effect for ceilings, which require a degree of aerial lightness, especially in drawing-rooms, boudoirs, and such like apartments. In these cases, therefore, the absorption is stopped by two coats of paint, and when these are quite dry and hard, a coat of what is called distemper colour is applied; that is, white lead ground in water, and diluted with size made from the parings of white leather and parchment skins. In ordinary apartments, fine whiting may be substituted in distemper work for white lead.

The painting of the woodwork of such apartments as are not fitted up with oak or other hard woods, is a process very similar to that employed upon plaster, not only when it is to be finished plain, but also as a ground-work for imitations of the foreign woods now in use; only each of the coats should be thicker and applied with still more attention to smoothness. The imitating of woods and marbles may be termed, in house-painting, a link between that which has been already explained and is essentially simple, and that which is really ornamental. It has of late been brought to such perfection, that in some cases where the real and the imitation oak are brought into juxtaposition, as at Abbotsford, it is scarcely possible, even after examination, to distinguish the imitation from the reality. Imitations of marble have in some cases been brought to equally great perfection, but this is far from being so general.

The process of painting imitations of woods, is in the first instance, as already observed, to lay a ground-work of four or five coats of paint, taking the greatest care that no brush marks remain. This requires much more time than applying the same number of coats for plain finishing; and the last coat instead of being flatted, is composed of equal portions of oil and spirits of turpentine. The shades and grain of the wood are given by thin glazings of Vandyke brown, terra de sienna, or umber, according to the kind of wood to be imitated; which colours are ground in water and mixed with small beer, the tenacity of which is sufficient to prevent it rubbing off by the application of the varnish which immediately follows. All imitations of woods are painted in this way, except wainscot, for which a thick substance is requisite, in order that it may receive the impression of an ivory or horn comb, by which the peculiar grain of that wood is imitated. The varnish employed upon work of this kind is copal, which of all the materials used by the painter is that in which he has most latitude. The price of copal varnish is from 10s. to 42s. per gallon; so here again he can suit his materials to the price which he receives for his work.

The imitation of marbles has nothing very peculiar in its mode of execution, being more like actual painting than that employed in imitating wood; and on this account it depends more on natural taste, than on mechanical skill.

The ornamental department is likewise making great strides towards its ancient excellence, and owing to the improved taste of the present age, is beginning to be somewhat in demand. What is meant by the ornamental department, is the decorating of the walls of apartments either by original designs of pannelling and borders, or by careful imitations of Raffaelle's arabesques, Watteau's grotesque pannellings, and the Pompeian frescos; as well as decorations in imitation of basso relievo, in white and gold, polychrome and various other styles.

The want of general instruction in art, and the prevalence of the use of paper hanging, have tended to retard the progress of ornamental painting; but the former cause, through the patriotism of an individual,[1] backed by a government that has the interest of all classes in view, is, by the establishment of schools for ornamental design, in a fair way of being removed; and the latter will soon give

[1] Mr. Ewart, formerly M.P. for Liverpool.

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way to the rapid improvement which is taking place in public taste.

It now only remains to notice what we term the scientific department of house-painting, or more properly (from the improved practice of the profession) interior decoration. The fact is now no longer disputed that the rules of the highest science and art can be made available in improving our most ordinary occupations; and in no case has this fact been made more apparent than in the application of the science of chromatics or the laws of harmonious colouring to the interior decoration of our dwelling-houses. Much attention is, however, requisite on the part of the house-painter, to the *proper* application of these laws in his practice. Every practitioner in the higher walks of art, has only such a style of colouring to study, as may be suited to the general character of his subjects; but the house-painter must vary *his* style, not only according to the uses of the apartments which he decorates, but the tastes of his employers, the style of the architecture, the situation of the house, and the quarter from which each apartment is lighted. He must confine himself to neither a vivid, sombre, warm, nor cold style; all must be equally at his command. Besides, an artist has the advantage of light and shadow in toning the colours in a picture; whilst those employed in decorative painting, are all liable to be placed in full light, and must necessarily be in themselves toned to prevent that unnatural crudeness so annoying to the eye. A picture may have many excellencies to compensate for defective colouring; it may excel in one or other or all of the qualities of drawing, expression, and composition; but beyond the mere handicraft department, the works of the decorator must depend solely for their effect upon harmonious colouring.

It would exceed our limits to give even an outline of the laws of harmonious colouring, as applied to house-painting, and shall, therefore, refer the reader to the only work which has yet been written on the subject,[1] and from which we make the following extract, relative to the tone and characteristic style of colouring peculiar to the various apartments of a dwelling-house.

"The tone or key is the first point to be fixed, and its degree of warmth or coldness will be regulated by the use, situation, and light of the apartment. The next point is the style of colouring, whether gay, sombre, or otherwise. This is more particularly regulated by the use of the apartment, and the sentiments which it ought to inspire; for, as Sir Joshua Reynolds says in regard to colouring, 'what may heighten the elegant may degrade the sublime.' Unison, or a proper combination of parts, is the next consideration.

"The tone or key is generally fixed by the choice of the furniture; for as the furniture of a room may be considered, in regard to colouring, in the same light as the principal figures in a picture, the general tone must depend upon the colours of which it is composed: for instance, if the prevailing colour be blue, grey, cool green, or lilac, the general tone must be cool; but if, on the other hand, it be red, orange, brown, yellow, or a warm tint of green, the tone must be warm. But, as stated before, there can be no pleasing combination of colours without variety. This, by judicious management, may be given without in the least interfering with the tone, for it is merely the general colour of the furniture which ought to fix the tone; and there may be the most decided contrasts in its parts, which, by the introduction of proper medial hues throughout the room, can be reconciled and united. Apartments lighted from the south and west, particularly in a summer residence, should be cool in their colouring; but the apartments of a town house ought all to approach towards a warm tone; as also such apartments as are lighted from the north and east of a country residence.

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"When the tone of an apartment is therefore fixed by the choice of the furniture, it is the business of the house-painter to introduce such tints upon the ceiling, walls, and wood work, as will unite the whole in perfect harmony. This is a difficult task. The colours of the furniture may be arranged by a general knowledge of the laws of harmony, but the painter's part cannot be properly added without the closest attention to the principles of art.

"The style of colouring is the next point to be fixed, and will depend entirely on the use of the apartment. In a drawing-room, vivacity, gaiety, and light cheerfulness should characterise the colouring. This is produced by the introduction of light tints of brilliant colours, with a considerable degree of contrast and gilding; but the brightest colours and strongest contrasts should be upon the furniture, the effect of which will derive additional value and brilliancy from the walls being kept in due subordination, although at the same time partaking of the general liveliness.

"The characteristic colouring of a dining-room should be warm, rich, and substantial; and where contrasts are introduced, they should not be vivid. This style of colouring will be found to correspond best with the massive description of the furniture; and gilding, unless in very small quantities for the sake of relief, should be avoided.

"Parlours ought to be painted in a medium style, between that of a drawing-room and dining-room.

"The most appropriate style of colouring for libraries is solemn and grave, and no richer colouring should be employed than is necessary to give the effect of grandeur, which can scarcely be done where one monotonous tint prevails; but care should be taken not to disturb the quiet and solemn tone which ought to characterise the colouring of all apartments of this description.

"In bed-rooms, a light, cleanly, and cheerful style of colouring is the most appropriate. A greater degree of contrast may here be admitted between the room and its furniture than in any other apartment, as the bed and window-curtains form a sufficient mass to balance a tint of equal intensity upon the walls. There may also, for the same reason, be admitted gayer and brighter colours upon the carpet.

"Stair-cases, lobbies, and vestibules, should all be rather of a cool tone, and the style of the colour should be simple and free of contrast. The effect to be produced is that of architectural grandeur, which owes its beauty more to the effect of light and shadow than to any arrangement of colours; yet they ought not to be so entirely free from colour as the exterior of a mansion, but should be in colouring what they are in use, a link between exterior simplicity and interior richness.

"Stair-cases and lobbies being cool in tone, and simple in the style of their colouring, will much improve the effect of the apartments which enter from them."

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[1] Hay's *Laws of Harmonious Colouring adapted to Interior Decoration*, Edinburgh, 1836, in 8vo, 3d ed.

Pair ‖ Pairing.

PAIR, two of a sort, a couple.

PAIRING, the uniting or joining in couples. The instinct of pairing is bestowed on every species of animals to which it is necessary for rearing their young, and on no other species. All wild birds pair; but with a remarkable difference between such as place their nests on trees, and such as place them on the ground. The young of the former, being hatched blind, and without feathers, require the nursing care of both parents till they are able to fly. The male bird feeds his mate on the nest, and cheers her with a song. As soon as the young are hatched, singing yields to a more necessary occupation, that of providing food for a numerous issue; a task which requires the care of both parents.

Eagles and other birds of prey build upon trees, or in other inaccessible spots. They not only pair, but continue in pairs all the year round; and the same pair procreates year after year. This at least is the case of eagles. The male and female hunt together, unless during incubation, at which time the female is fed by the male. A greater number than a single pair are never seen in company.

Gregarious birds pair, in order probably to prevent discord in a society confined to a narrow space. This is the case particularly with pigeons and rooks. The male and female sit on the eggs alternately, and divide the care of feeding their young.

Partridges, plovers, pheasants, sea-fowl, grouse, and other kinds that place their nests on the ground, have the instinct of pairing; but they differ from such as build on trees in this respect, that after the female is impregnated, she completes her task without needing any help from the male. Retiring from him, she chooses a safe spot for her nest, where she can find plenty of worms and grass-seed at hand; and her young, as soon as hatched, take foot, and seek food for themselves. The only remaining duty incumbent on the dam is, to lead them to proper places for food, and to call them together when danger impends. Some males, provoked at the desertion of their mates, break the eggs if they stumble on them. Eider-ducks pair like other birds that place their nests on the ground; and the female finishes her nest with down plucked from her own breast. If the nest be destroyed for the down, which is remarkably warm and elastic, she makes another nest as before. If she be robbed a second time, she makes a third nest; but the male furnishes the down.

Pairing birds, excepting those of prey, flock together in February, in order to choose their mates. They soon disperse, and are not seen afterwards except in pairs.

Pairing is unknown to quadrupeds that feed on grass. To such it would be useless, as the female gives suck to her young whilst she herself is feeding. If M. Buffon deserves credit, the roe-deer form an exception. They pair, though they feed upon grass, and have but one litter in a year.

Beasts of prey, such as lions, tigers, wolves, pair not. The female is left to shift for herself and her young, which is a laborious task, and often so unsuccessful as to shorten the life of many of them. Pairing is essential to birds of prey, because incubation leaves the female no sufficient time to hunt for food. Pairing is not necessary to beasts of prey, because their young can bear a long fast; and we may add another reason, viz. that they would multiply so fast by pairing as to prove troublesome neighbours to the human race. Amongst animals that pair not, males fight desperately about a female. Such a battle amongst horned cattle is finely described by Lucretius. Nor is it unusual for seven or eight lions to wage bloody war for a single female.

The same reason that makes pairing necessary for gregarious birds obtains with respect to gregarious quadrupeds, those especially who store up food for winter, and during that season live in common. Discord amongst such would be attended with worse consequences than even amongst lions and bulls, who are not confined to one place. The beavers, with respect to pairing, resemble birds that place their nests upon the ground. As soon as the young are produced, the males abandon their stock of food to their mates, and live at large, but return frequently to visit them whilst they are suckling their young.

Paisley.

PAISLEY, the principal town of Renfrewshire, and, in point of manufacturing importance and population, the second in Scotland, is finely situated on the banks of the White Cart, about three miles south of the river Clyde. The ancient and principal part of the town occupies the summit and slopes of a beautiful declivity, the eastern base of which is washed by the river, which divides the burgh into two parts, that on the east side being styled the New Town, from its more recent erection. Paisley is generally considered as the ancient Vanduaria of Ptolemy, and as having been a Roman town or station during the presence of these invaders in the northern part of Scotland. As late as the beginning of the last century, considerable vestiges remained of a Roman camp on the western side of the hill on which Paisley is built; but these have long since been obliterated by the progressive extension and improvement of the town. The latitude of Paisley is 55. 48. north, and the longitude 4. 26. west. The climate is temperate, but humid. Inflammatory and pulmonary complaints are prevalent, and infectious diseases have been of rather frequent occurrence in its history. In 1645, a pestilence committed great ravages in this place; and in 1765 dysentery prevailed to an alarming extent. In 1771, pleurisy carried off numbers of the inhabitants; and a virulent influenza visited it in 1803, 1830, 1831, and in the beginning of 1837. Paisley is not, however, considered as unhealthy, nor is its mortality above the average of other large manufacturing cities. Whether the Roman town or station called Vanduaria was a place of any size or importance, ancient chronicles are entirely silent. A dark cloud overhangs the history of Paisley till about the year 1163, when Walter, the first Stewart, founded a monastery on the eastern bank of the Cart, opposite to what is now termed the Old Town of Paisley. At this period there does not appear to have been a village or hamlet, however small, in existence; but the protection which the monastery afforded in those rude times, and the multitude of pilgrims, travellers, and persons of distinction, who frequented it, gradually induced a population to assemble in its vicinity; and a village of some extent made its appearance on the western bank of the river, and began slowly to clamber up the gentle slope of the hill on that side. In 1220, the monastery was elevated to the dignity of an abbey, and many valuable privileges were subsequently conferred upon it by the pope, and by its founder and successive patrons. Its jurisdiction and revenues were very extensive, extending to, and being derived from, localities at a great distance; its abbots were commonly men of the highest family connections, and appear frequently as prominent actors on the stage of Scottish civil and ecclesiastical history. After the Reformation, the revenues and privileges of this ecclesiastical establishment were bestowed upon Lord Claud Hamilton, and have since become the property, though greatly reduced, of the noble family of Abercorn. A considerable part of the ancient abbey still remains, and is in excellent preservation. The skeleton of a beautiful window, thirty-five feet in height by eighteen in breadth, almost the only fragment of the more ancient part of the building, has been much admired for its size, lightness, and fine proportions. The external architecture of the remaining portion is perhaps scarcely equal to that of some other ecclesiastical edifices in Scotland; but the ap-

Paisley. pearance of the nave, which is occupied as a parish church, is grand and striking in no ordinary degree; and some few fragmentary remains of the old monastery exhibit fine specimens of the purest Gothic. Before the accession of the Stuart family to the throne of Scotland, their burying-place was in the abbey; and even after that event, two of its members were interred there, namely, the queen of Robert II. in 1387, and Robert III. in 1406. The tomb of Marjory Bruce, the daughter of Robert I. is still to be seen in the famous sounding aisle, now occupied as a burial-vault by the Abercorn family.

Notwithstanding the wealth and manufacturing importance of Paisley, it is only a burgh of barony; but its privileges are so very considerable as almost to equal those of a royal burgh. Previously to 1770, the burgh had a vote in the election of a member of parliament for the county. Now, by the Scottish Reform Act, Paisley sends a member to represent it in parliament. The constituency in 1837 was 1484. Formerly the government of the town was vested in a provost, three bailies, and seventeen councillors; but by the Scottish Burgh Reform Act there are now a provost, four bailies, and ten councillors.

In 1553, John Hamilton, the last abbot, conveyed, by a deed, the revenues and privileges of the abbacy to Lord Claud Hamilton, then a child of ten years of age: he was afterwards deprived of the latter, on account of his adherence to the fortunes of Queen Mary, but in 1591 they were restored, with the title of Lord Paisley. In 1653, the second Earl of Abercorn disposed of his interest in the abbacy to the Dundonald family; and in 1658 the magistrates and council purchased this superiority, and since that time Paisley has held directly of the crown. The old valuation of the burgh-lands was a thousand pounds Scotch. The town's revenue, from various sources, such as lands and houses, river-dues, and various other civic items, amounts to L.3843. 12s. 7d., and the supposed value of the burgh property is about L.50,000; but, deducting debts and other obligations, its nett amount may be L.20,000.

The topography of Paisley and its vicinity is not very remarkable. Previously to the year 1736, the whole of this district was included in one parish, known by the name of the parish of Paisley; but since that time the burgh has been divided into three parishes, the High, the Middle, and the Low. The Abbey parish now comprehends the New Town, which, with a trifling exception, is separated from the burgh by the river Cart, and the populous villages of Johnstone, Elderslie, Thorn, Quarrelton, Nitsil, Hurlet, and Dovecote Hall, with the country districts. To the north, and affording a noble view from the eminence on which Old Paisley is chiefly built, extends the great plain of the lower valley of the Clyde, anciently called Strathgryffe. On the south, the Gleniffer, or Paisley Braes, distant about three miles, swell gently up to the height of 760 feet above the surface of the Cart. The soil is of a mixed character, generally poor and thin, but in many places rich and fertile. From the heights just mentioned descend a variety of minor streams, of great utility to the agriculturist and the manufacturer, and adding to the richness and beauty of the scenery. The surface of the country in the neighbourhood, with the exception of that to the north, which is flat, is agreeably diversified, and broken into gentle swells and soft declivities, which, with the mixture of gentlemen's seats, farm-houses, bleaching-fields, and other public works, confers a picturesque and animated character upon the entire vicinage. Valuable minerals abound in the parish, such as coal, limestone of the coal formation, and ironstone; though the latter is not smelted, at least to any extent, but is sent to the Lanarkshire furnaces. There are very extensive coal-pits wrought in the neighbourhood, chiefly at Johnstone; and in that vicinity, and at Hurlet, the chemical works of the Messrs Wilson at Thornly are on a very large scale. Very fine freestone is also obtained in the neighbourhood. Paisley.

As it is chiefly, however, to its being one of the principal manufacturing stations in the kingdom that Paisley owes its celebrity, we shall now present a brief sketch of the history, progressive improvement and increase, and present extent, of its principal manufactures. There is no certain account as to the precise period when the art of weaving was introduced. It appears, however, that the manufacture of linen was carried to a considerable extent during the last century. Shortly after the union, the spirit of manufacturing enterprise sprung up in the west of Scotland, and Paisley was not slow in availing itself of the general impulse. Craufurd, describing the state of Paisley in 1710, observes, "That which renders this place considerable, is its trade of linen and muslin, where there is a great weekly sale in its markets, of those sorts of cloth; many of the inhabitants being chiefly employed in that sort of manufactory." From 1744 to 1784 the linen manufacture increased in amount from L.18,886. 15s. 10d. to no less than L.184,385. 16s. 6½d. About the year 1722, the manufacture of linen thread was introduced into Paisley, and carried on to a large extent. For several years it reached the amount of L.100,000 annually. Cotton thread, having superseded that made from linen yarn, is manufactured to a very considerable extent, and forms one of the principal manufactures of the place. In 1760, silk gauze began to be manufactured in Paisley; and in a short time the skill and ability with which this manufacture was prosecuted caused its abandonment by the manufacturers of Spitalfields, the original seat of the silk manufacture in Great Britain. This manufacture flourished extensively until near the close of the last century. From 1772 there existed also a considerable manufacture of ribbons, and other articles in silk. It has been calculated, that in 1784 the value of the manufactures of Paisley, in silk gauzes and other silk goods, linen lawns, linen gauze, and sewing thread, was L.579,185. 16s. 6d., and that in 1769 it amounted to L.660,385. 16s. sterling. In 1744, only 867 looms were employed in the weaving of linen; and forty years afterwards no fewer than 5000 looms were engaged in the manufacture of silk, the produce of which amounted to L.350,000.

Towards the end of the last century, from the caprice of fashion, and the gradual introduction of the cotton manufacture, the making of silk goods declined rapidly; but a new species of manufacture sprung up, which has since been carried to a much greater extent. The manufacture of shawls, of cotton, silk, and fancy woollen fabrics, was introduced, and has now become the staple trade of Paisley. Although little more than forty years have elapsed since its introduction, this manufacture is so extensive, that in 1834 the value was calculated to be about a million sterling; and since then it is understood to have increased considerably.

Previously to the present century, fine shawls had been manufactured in this country, chiefly at Norwich and Stockport in England, where they were made in imitation of the rich India shawls. The latter, from their high price, were beyond the reach of all but a few wealthy individuals, when the manufacturing skill and enterprise of Paisley embarked in the manufacture, and, by successive inventions and improvements in the loom, and in the kind and quality of the materials, prosecuted for a long series of years, succeeded in realizing a nearly perfect imitation of those oriental fabrics, in colours, texture, and design, and at a mere fraction of the cost. Besides the extraordinary cheapness, the variety of new and beautiful fabrics and designs which have been introduced into the shawl manufacture have largely contributed to its extent and success. The manufacture of shawls is almost wholly confined to Paisley; but a considerable proportion of these find their way to the

Paisley. Glasgow markets for home and foreign sale. The kinds produced are various in quality and cost, and there is a great variety in the styles and fabrics. Some are wholly made of silk, but these are not now much in demand; others of silk and cotton, and a great many of Persian and fancy wools mixed with both or either. Thibet-cloth shawls, a very rich and fanciful fabric; Chenille shawls, a beautiful imitation of silk velvet; Canton crape shawls; and various other and newer kinds, of every possible variety in size, texture, pattern, and price; are produced from the looms of Paisley, with a rapidity and abundance which, whilst it tends occasionally to overload the market, affords satisfactory evidence of the manufacturing skill and resources of Paisley. The present annual amount of the trade and manufactures of Paisley has been roughly calculated at nearly two millions sterling. To give any thing like a view of the various inventions and improvements in the art of weaving, by means of which Paisley has attained its present eminence as a chief seat of the silk and cotton manufactures in Scotland, would swell this article beyond all due bounds. The hasty sketch which we have supplied affords some general data to the reader, who may consult, if he wishes for more minute information, Wilson's Survey of Renfrewshire; Craufurd's Description of the Shire of Renfrew, with Robertson's continuation; and the New Statistical Account of Scotland. The spinning of cotton yarn is also extensively carried on by Paisley manufacturers in the town and parish, but there are no data to be relied on for ascertaining its annual amount. Bleaching and dyeing are, as might be expected, prosecuted to a very considerable extent. Soap-making is a trade of some antiquity and importance; and malting, the distillation of raw spirits, and silk throwing, have also a considerable capital embarked in them.

Under the head of General Statistics we may notice the increase of the population in Paisley from 1791 to 1835. In 1695 the population of the town of Paisley, exclusively of the Abbey parish, where there were then very few houses, was only 2200. In 1755, sixty years after, it amounted in the town and Abbey parish to 6799; and in 1781 to 11,100 in the town alone, the population of the Abbey parish not being given in the register.

In 1791 the total population was	24,592
... 1801	31,179
... 1811	36,722
... 1821	47,003
... 1831	57,466

The population may now be assumed at about 65,000, according to the ordinary increment of increase. Thursday is the market-day in Paisley, and there are four fairs annually, which last three days each. The races at St James's Fair are well known in the west of Scotland, and attract great numbers from the surrounding districts. For the last three or four years these races have been much frequented by the sporting world. Race-horses of high celebrity have made their appearance on the course; and a greal deal of money, it is understood, has changed hands. Paisley is abundantly supplied with the means of external communication; and when the Ayrshire and Greenock railways are completed, few towns in the empire will possess equal facilities for traffic or travelling. By the canal betwixt Glasgow, Paisley, and Johnstone, no fewer than 423,186 passengers were conveyed, from the first of October 1835 to the first of October 1836. From the latter period, however, to the first of October 1837, the number had decreased to 386,157, owing to other means and modes of locomotion being opened up. After the railway to the Clyde near Renfrew, which is from two to three miles in length, was opened, in the spring of 1837, about 50,000 passengers passed along it, going up and down the river, during the first seven months; and no fewer than 100,000 persons were carried by coach to and from Glasgow, from October 1836 to the same time in 1837. The carriage of goods on the canal has increased from 48,991 tons in 1831, to 67,305 tons in 1836. The yearly returns of the post-office afford additional evidence of the growing prosperity of Paisley. Paisley.

In 1720 the amount was only	L.28	13	0
... 1769	223	3	8
... 1809	2814	17	4
... 1834	3194	0	0

The river Cart is navigable to Paisley for vessels of from sixty to eighty tons burthen; but the improvements in progress upon the river, by deepening, and removing various other obstacles to the navigation, for which an act of parliament has lately been obtained, are expected greatly to increase the facility of external traffic. The river dues in 1835 amounted to L.260. An act of parliament has also been obtained to make a cut from the Forth and Clyde Canal, to enter the Clyde as near as possible to the confluence of the Cart with that river; an undertaking which will be highly advantageous to the Paisley manufacturers, by affording them a cheaper and more expeditious transit for their goods to London and the continental markets, for which a large portion of their manufactures are prepared.

The antiquities of Paisley, with the exception of its abbey, of which we have already spoken, are hardly worth mentioning. There are a few old castles in the vicinity, in a state of lesser or greater dilapidation; but, with the exception of that of Crookston, once the property of the family of the feeble and worthless Darnley, and which, from its commanding situation on a richly-wooded slope, about four miles to the east of Paisley, and its air of venerable antiquity, forms a most picturesque feature in the general landscape, none of them possesses much interest, either historically, or as agreeable accessories in the general scenery.

Notwithstanding the enterprising and intellectual character of the inhabitants of Paisley, the means of education are not so abundant as might be expected. From a report by the presbytery to the General Assembly in 1834, the number of schools in the town and Abbey parish was only sixty-five, and the scholars amounted to 4776. Since then, however, considerable exertions have been made to remedy this deficiency. Government lately granted L.700 to the burgh for educational purposes; and this sum, aided by liberal subscriptions from the citizens, and the exertions of the general session and various philanthropic individuals, has provided the means of education for a large additional number.

The town is well lighted with gas, and an act of parliament has lately been obtained by a public company to supply it with water from the neighbouring heights. The assessment for the poor for 1838 is L.3500 for the three town parishes. The only public building in Paisley of any importance, with the exception of the abbey, is the county-jail and public offices, an edifice of considerable extent, castellated in style, and standing in a fine situation on the western bank of the Cart. The news-room at the cross is also a handsome building. There are three bridges over the Cart, connecting the Old and New Town of Paisley, but none of them is particularly remarkable.

The civil history of Paisley affords little to interest or deserve the attention of the general reader. Its ecclesiastical history is curious and interesting, but supplies few points sufficiently salient and compact to be entered upon in so brief a sketch. The famous "Black Book of Paisley," which was long supposed to have been a history of Paisley and its monastery, has been ascertained to be the *Scoti-chronicon* of Fordun, a monk of the fourteenth century. Manuscript copies of this curious old work, with continuations by Bowmaker and others, are in the College Li-

Paita ‖ Palæmon.

brary at Edinburgh, and in the British Museum. The Chartulary or Register of the Monastery of Paisley, printed in 1832, at the expense of the Earl of Glasgow, president of the Maitland Club, is a valuable document, containing much curious information respecting those primitive times. Previously to the Reformation, Paisley was a place of little importance. The neighbourhood of its abbey, however, with the presence of its lordly abbots and their distinguished guests, conferred upon it considerable dignity even then, and drew into it the neighbouring gentry, who, down to a comparatively recent period, had family mansions in the town. The inhabitants early embraced the doctrines of the Reformation, notwithstanding the naturally adverse influences of their great monastic establishment; and displayed their attachment to these on various occasions during the civil wars and prelatical persecutions of the seventeenth century. In 1715 and 1745, they showed equal zeal for the house of Brunswick; and the burgh had to pay a fine of L.500 to the Young Chevalier, at the latter period, as a composition for its anti-Jacobite predilections. The magistrates afterwards memorialized government for compensation, but they never obtained it. In 1597, the queen of James VI. honoured the inhabitants with a visit to their town, when it would appear that the royal entertainment fell so heavy on the burgh funds, that in 1617, when her royal consort also visited it, the civic dignitaries prudently forbore so costly a welcome, but in lieu thereof employed "a prettie boy, a son of a Sir James Semple of Beltrees," to make him a speech, which, from the extracts of it we have seen, was judiciously spiced for James's royal ear. Its modern history is comprised in the progress of its manufactures, and the improvement of the town in all its interests and appearances, of which we have supplied this brief analysis.

PAITA, or PAYTA, a town of Peru, in the department of Truxillo. It stands on a bay of the same name, situated in 5. 2. of south latitude. A hard sandy beach extends round the harbour, which is completely sheltered from all prevailing winds. The port is a rendezvous for American whale-ships. It is the seaport of Piura, fourteen leagues in the interior, and carries on a considerable coasting trade. The exports from Paita are cinchona, rhatany, silver, and wool. This town has suffered as much from the invasions of the buccaneers as any port of the Pacific. It was also burned by Lord Anson in 1741, and by Lord Cochrane in 1810; yet the importance of its position has always led to its reconstruction. The population amounts to about 3000.

PAITAN, a district on the north-eastern coast of Borneo, containing a bay and river of the same name. The bay is greatly encumbered with shoals, and the coast on both sides is extremely foul. The country around produces abundance of camphor.

PAKIR, a seaport of Arabia, situated on the coast of Hadramaut, from which a considerable trade is carried on with India. The environs abound in cattle, grain, and dates. Pakir is twenty-five miles east of Dofar.

PALACE, PALATIUM, a name generally applied to the dwelling-house of a king, prince, or other great personage. It takes different epithets, according to the quality of the inhabitants, as imperial palace, royal palace, pontifical palace, cardinal palace, ducal palace, episcopal palace, and so on.

PALACHY, a town of India, in the province of South Coimbetoor, containing 300 houses, and a small temple, with a small fort adjacent. Palachy is 121 miles south by east from Seringapatam. Long. 77. 8. E. Lat. 11. 47. N.

PALÆMON, Q. RHEMMIUS, a famous grammarian of Rome, in the reign of Tiberius, who was born of a slave, at Vienza. We are told he was first brought up to the business of a weaver; but attending his master's son to school, he profited by this opportunity of attaining knowledge, and acquired so much skill in common learning, that he obtained his freedom, and became a teacher or preceptor at Rome. His claim to learning cannot be questioned, since he is recorded as a scholar even by Juvenal. Only some fragments of his works remain.

Palæolo-gus ‖ Palapetty.

PALÆOLOGUS, MICHAEL, a very able man, who was governor of Asia under the Emperor Theodorus Lascaris; and who, by various stratagems and cruelties, procured the empire for himself and his posterity. See CONSTANTINOPOLITAN HISTORY.

PALÆPAPHOS, a town of Cyprus, where once stood a temple of Venus; and an adjoining town called *Neo Paphos*, where St Paul struck Elymas blind, and converted the proconsul Sergius Paulus.

PALÆSTRA, in Grecian antiquity, a public building where the youth exercised themselves in wrestling, running, playing at coits, and other feats of strength and skill. To prevent the combatants from hurting themselves by falling, the bottom of the palæstra was covered with dust or gravel. Some think that the palæstra was only a part of the gymnasium. Many authors also imagine that the palæstra was of two kinds, the one for the exercise of the body, the other for the cultivation of the mind; but the derivation of the word seems to confine it exclusively to bodily exercise.

PALALAIKA, or BALALAIKA, a rude kind of guitar with two strings, which is common in Russia.

PALAMEDES, a Greek chief, son of Nauplius, king of Eubœa, by Clemene. He was sent by the Grecian princes who were going to the Trojan war, to bring to the camp Ulysses, who, in order to avoid the expedition, pretended insanity, and, the better to carry on the imposition, often harnessed different animals to a plough, and sowed salt instead of barley. But Palamedes soon discovered the cheat. He knew that regret to part with Penelope, whom Ulysses had lately married, was his only reason for pretending insanity; and to demonstrate this, Palamedes took Telemachus, of whom Penelope had lately been delivered, and put him before his father's plough. Ulysses turned the plough a different way, not to hurt his child. He was therefore obliged to attend the Greek princes to the war; but a mortal enmity took place between Ulysses and Palamedes. The king of Ithaca determined to take every opportunity to distress him; and when all his attempts were frustrated, he had recourse to a base stratagem, and had Palamedes unjustly accused and convicted of treason, and stoned to death by the army. Palamedes was a man of learning as well as a soldier; and, according to some, he completed the alphabet of Cadmus by the addition of the four letters θ, ξ, χ, φ, during the Trojan war. To him also is attributed the invention of dice and backgammon; and it is said that he was the first who regularly ranged an army in order of battle, and who placed sentinels round the camp, and excited their vigilance and attention by giving them a watchward.

PALAMOW, a district of Bengal, situated on the western frontier, between the 22d and 25th degrees of north latitude. It is bounded on the north by Rhotas; on the south and west it touches different wild districts of Gundwaneh; and on the east it has Ramgur. It is the least populous and worst cultivated of any district in British India. It contains, however, both iron and coal; but the natives are not sufficiently advanced in civilization to explore the mines. The Burnah or Cayle River, which falls into the Soane, flows through it; and on its stream timber and other heavy articles might be floated down to Patna, if the country were more civilized. The principal towns are Palamow and Jaynagur. The former, the chief town of the district, is situated in a valley on the eastern side of the Cayle River, and is the residence of a rajah or zemindar. Long. 78. 10. E. Lat. 23. 52. N.

PALAPETTY, a town of Hindustan, in the district of

Palar ‖ Pale.

Dindigul, thirty miles north from the town of Dindigul. Long. 78. 10. E. Lat. 10. 40. N.

PALAR, a river of the south of India, which has its rise in the province of Mysore, and, after a course of 200 miles, falls into the Bay of Bengal near Sadras.

PALARIA, amongst the Romans, a kind of exercise performed at a stake by the soldiers. The stake being fixed in the ground, and six feet in height above it, the young undisciplined soldiers advanced against it, armed with a hurdle and cudgel instead of a sword and shield, and went through all the rules of attack and defence, as if actually engaged with an adversary. Sometimes they stood at a distance, and attacked with missive weapons; at the same time using all the requisite motions for defending themselves, and warding off what might be thrown against them.

PALATINATE, a province or signiory, possessed by a palatine.

PALATINATE of the Rhine, a province of Germany, divided into two parts by the Rhine, called the Upper and Lower Palatinate.

PALATINE, or COUNT PALATINE, a title anciently given to all persons who had any office or employment in the prince's palace, but afterwards conferred on those delegated by princes to hold courts of justice in the provinces, and on such amongst the lords as had a palace, hat is, a court of justice, in their own houses.

PALATINE-GAMES, in Roman antiquity, were games instituted in honour of Augustus by his wife Livia, after he had been enrolled amongst the gods. They were celebrated in the palace, whence the name, and were confirmed by the succeeding emperors. Some authors say that these games were instituted in honour of Julius Cæsar, and others again confound them with the Ludi Augustales; but neither of these opinions seems to be well supported.

PALATSHA, a village of Anatolia, in Asia Minor, situated near the coast of the Mediterranean. It is supposed by some to be the ancient Miletus, whilst others believe the ruins to be those of Myus, an ancient town, ultimately incorporated with Miletus. Long. 27. 12. E. Lat. 37. 31. N.

PALAWAN ISLE, a large island in the Eastern Seas, estimated at 275 miles in length, and thirty-two miles in average breadth. It stands between the northern extremity of Borneo, with which and the Philippines it forms an extensive chain of islands. The country is described as being flat to the bottom of the hills. Its productions are cowries, wax, tortoise-shell, and sea-slug or *biche de mer*, the last being abundant. It contains much ebony and laka-wood; also hot springs and mines of gold.

PALAZZOLA, a city of the island of Sicily, in the intendancy of Siragosa, and district of Noto. It is situated on a high mountain, the ancient Erbessus, in a humid atmosphere, 130 miles from Palermo. It contains 8500 inhabitants, chiefly cultivators.

PALCATI NOR, or BALKASH, a lake of Northern Tartary, extending about 200 miles from north to south, and 110 from east to west. It is situated 700 miles east from the Aral. Its waters, though somewhat brackish, are not altogether unfit for drinking. It contains several small lakes near its southern extremity. On the west it has the country of the Kirghisses, and on the east the great plateau of Soongaria.

PALCOTE, a town of Bengal, in the province of Bahar, and district of Chuta Nagpore, 200 miles west by north from Calcutta. Long. 85. 0. E. Lat. 22. 58. N.

PALE, a little pointed stake or piece of wood used in making enclosures, separations, and the like. The *pale* was an instrument of punishment and execution amongst the ancient Romans, and still continues so amongst the Turks.

Palem-bang.

PALEMBANG, a district of Sumatra, on the north-eastern coast, extending along the river Palembang, which rises within two days' journey of Bencoolen, and runs nearly across the island. It is upwards of a mile in breadth opposite to the town of Palembang and the Dutch factory, and may be navigated by vessels which do not draw more than fourteen feet depth of water. In its lower parts, towards the sea-coast, the country is described as flat and marshy, and, with the exception of a few tracts, entirely unfit for cultivation. The produce of this country consists chiefly of pepper, rattans, gambir, silk, cotton, damor, ivory, cat's-eyes, sulphur, salt, wax, rice, benzoin, indigo, tobacco, areca, buffaloes, and gold. The pepper trade is very profitable. The port is much frequented by trading vessels, chiefly from Java, Bally, Madura, and Celebes, which bring rice, salt, and cloth, the manufacture of these islands. With opium, the piece-goods of India, and European commodities, it is supplied by the Dutch from Batavia, and by interlopers. These in return receive pepper and tin, which were formerly monopolized by the Dutch East India Company to the amount of about two millions of pounds, one third of which was shipped at Batavia for Holland, and the remainder sent to China. The interior parts of the country are divided into provinces, each of which is assigned as a fief or government to the royal family, or to the nobles, who commit the management to deputies, and are little interested about the welfare of their subjects. The power of the monarch is unlimited; but not maintaining any permanent body of troops, his nobles often contemn his orders; and power in this case belongs to the stronger party. He has no revenue except what arises from his monopolies, and from the produce of the customs; but the amount of these, especially that arising from pepper and tin, is considerable. The population, with the present rulers, is said to have come, a great portion of it, originally from Java; though, according to the opinion of the best authors, Palembang is the original country of the Malay race. The policy of the princes having always been to encourage foreign settlers, the city and lower parts of the river are in a great measure peopled with natives of China, Cochin-China, Camboja, Siam, Patani, on the coast of the peninsula; Java, Celebes, and other eastern islands. In addition to these, the Arabian priests are described by the Dutch as a very numerous and pernicious tribe, who impose upon and plunder the credulous inhabitants, and are nevertheless held by them in great reverence. The Mahommedan religion prevails throughout all the dominions of the sultan, with the exception of a district near the sea-coast, where the natives live in the woods like the brute creation. The natives are described by the Dutch as devoid of every good quality. But the Dutch are generally at enmity with the natives in their colonies, irritating them by their tyranny and oppression; and hence it is not unusual for others who treat them differently to find their characters exactly the reverse of the portrait drawn of them by the Dutch. They have, besides, little knowledge of their character, owing to the jealousy and alarm of the Palembang government at every attempt to penetrate into the interior.

In the year 1812 the kingdom of Palembang was conquered; and the sultan, who had made himself universally odious by his cruelties, having been dethroned by a handful of British troops under the orders of Colonel Gillespie, his brother was raised to the throne in his stead. The expedition which was sent against this tyrant, being detained in the river of Palembang in the ascent to the capital, and Colonel Gillespie learning that the sultan in his rage had come to the resolution of putting to death all the wealthy Chinese and the other merchants, penetrated to the capital with a small party of about seventeen grenadiers, and, entering the palace, fortified themselves until

Palembang ‖ Palencia.

the other troops arrived, and thereby prevented the intended massacre, and completed the overthrow of the sultan's despotism. (F.)

PALEMBANG, the capital of the above district, and a great emporium of inland commerce. It is situated in a marshy tract of flat ground, a few miles above the delta of the river, and about sixty miles from the sea. It is so intersected by the branches of the river, forming a number of islands, that it has received the appellation of the City of Twenty Islands. It extends about eight miles along the banks of the river. The houses of the sultan and his son are square areas, surrounded with very high brick walls. Each of these palaces contains several detached buildings of the pavilion form, having portions of ground planted with fruit-trees and ornamental shrubs. In front of these palaces is an extensive battery facing the river. There is also a lower range of batteries; and between the two is seen the Maidan or Plain, at the extremity of which appears the hall where the sultan gives audiences to the public. The sultan, before the arrival of the British, had been engaged in the construction of a new harbour, for which he had found materials in the Dutch factory, which he had demolished. It joins the inner palace, but the buildings are still incomplete. A large reservoir of water, with pleasure-boats in it, occupies the middle of this area, which is surrounded by numerous detached buildings for the females of the court. The principal mosque is a pretty large building, nearly square; and adjoining it is a high octagonal tower, from which the muezzin calls the people to prayers. The houses of the common people are made of bamboos, with mats, and thatched. Some of the houses float on the river, to the banks of which they are attached. About two miles above Palembang the river divides into two large branches; that on the left leading to a country-seat of the sultan, consisting of several bungalows and gardens delightfully situated on a cluster of small islands. The inhabitants amount to between 20,000 and 30,000, and consist of Malays, Chinese, and Arabs. Long. 104. 54. E. Lat. 2. 58. 51. S. (F.)

PALEMBANG, the river on which the city of the same name is situated, rises within two or three days' journey of Bencoolen, and falls into the Straits of Banca. The river, with the exception of the bar at its mouth, on which there are two fathoms and a quarter, has a depth sufficient to carry a frigate as far up as the town. It is of considerable breadth, with low and woody banks.

PALEMERDY, a town of Hindustan, in the Southern Carnatic, district of Madura, thirty-one miles south-east from the town of Madura. Long. 78. 23. E. Lat. 9. 26. N.

PALENCIA, a province in Spain, forming part of the ancient kingdom of Leon. It extends 145 square leagues, and the number of its inhabitants is 118,064, a density of population much greater than the general average of the kingdom presents. As the province is well watered, the riches and population, which in Spain must arise from the abundance of that element, are on the advance. The rivers that water it discharge themselves at last into the Duero, and are the Pisuerga, the Carrion, the Arlanza, and the Arlanzon. The country is generally fertile in the valleys, and yields wheat, barley, and wines. There are some coarse woollen manufactories scattered over the province, as well as in the capital city. The Canal of Castille runs through this province as far as it is executed. This, like the Canal of Aragon, is designed to promote two important objects, that of internal navigation and that of irrigation. The part of this valuable and costly work that is completed begins in the village of Alar del Rey, in latitude 42. 51., taking its water from the Pizuerga, the left bank of which it follows. It enters the kingdom of Leon by crossing that river, and then continues on its right bank, crossing also the Cieza, when it makes a turn to the city of Palencia, and terminates in the Carrion, a little below it. A branch called the Canal de Campos runs from it to the westward, towards Beceril. The masonry of this work is stupendous and well executed, as are all the locks, sluices, and other appendages. Such great operations always proceed slowly in Spain, and the recent struggles have created considerable impediments; but if the project be successfully pursued, and the original plan completed, this canal will connect itself with that of Aragon, and thus create an internal navigation across the whole of Spain. There are made in this province 500,000 hogsheads of wine, and 2000 of brandy. It possesses 3050 horses, 6500 mules, 3800 asses, 9300 oxen, 318,500 sheep, 11,300 goats, and 5500 pigs. It is in the captain-generalship of Zamora, and enjoys the privileges and laws of Castille.

Palencia ‖ Pales.

PALENCIA, a city of Spain, the capital of the province of Leon. It is situated on the banks of the river Carrion, after that river has been increased by the junction of the Cieza. It is the see of a bishop, and has a large and ancient cathedral. The country around produces good wheat, barley, and wine, especially in moist summers; but it has a barren appearance, from being almost wholly destitute of trees. It is a manufacturing place, and furnishes blankets, coverlets, baize, serges, and hats, to a great portion of the inhabitants of its own and the surrounding provinces. It is not considered as a healthy city, from its vicinity to a most pestiferous stagnant lake called Nava. It is situated in longitude 4. 34. west, and latitude 42. 10. north, has a population of 8292 souls, and contains five churches, eleven monasteries, and two hospitals.

PALENGA, a village of Hindustan, in the province of Sinde, situated in the route from Hyderabad to Luckput Bunder. Lat. 24. 19. N.

PALERMO, a province or intendancy of the island of Sicily, belonging to the kingdom of Naples. It is formed out of the Val di Mazzara, and some portions of the Val di Demona. It is situated on the sea-shore, which is its western boundary, and is bounded on the east by Messina, on the south by Calataniferra and Girgenti, and on the east by Trapani. It is divided into four districts, viz. Palermo, Cefalu, Corleone, and Termini, and contains 410,000 inhabitants. The capital of the island, as well as of the intendancy, is the city of Palermo. It stands upon a beautiful gulf of the same name near Cape Gallo. It has a fine mole running out nearly a quarter of a mile from the arsenal, with a lighthouse, which forms a convenient harbour. The city is built upon a fertile plain; and the air in general is salubrious, but in some parts malaria is generated in autumn. Most of the houses have fountains, which contribute much to cleanliness. It is a well-built and not inelegant city. The most prominent buildings are the royal palace and the cathedral. There is an university, with a library, and a good observatory. Many fine specimens of Moorish architecture are still to be seen. The trade is considerable, and includes many articles produced in the island. It contains about 180,000 inhabitants. Long. 13. 20. 15. E. Lat. 36. 6. 44. N.

PALES, in Pagan worship, the goddess of the shepherds, to whom they offered milk and honey, in order that she might deliver them and their flocks from wild beasts and infectious diseases. This goddess is represented as an old woman. Her festivals, called *Palilia*, were celebrated on the 21st of April, the day on which Romulus began to lay the foundation of the city of Rome; the ceremonies consisting in burning heaps of straw, and leaping over them. Some call the festival *Parilia* (*quasi a pariendo*), because the sacrifices were offered to the divinity for the fecundity of the flocks.

PALESTINE.

Palestine. PALESTINE, though a country of limited extent, has yet been the scene of events that will ever be memorable in the history of the world. It was in this fruitful land, flowing with milk and honey, that the chosen people of God, redeemed from Egyptian bondage, and crowned with conquest, were appointed to rest from their toils, after their long and laborious pilgrimage through the wilderness. Here they dwelt in peace, and in the enjoyment of all earthly blessings. Corrupted by prosperity, they provoked the vengeance of heaven by their ingratitude and rebellion, and were again, for their iniquities, swept into captivity in an unknown and hostile land. Restored to their country through the favour of the Persian king, they relapsed into their former evil courses; and filling up the measure of their guilt by putting to death the promised Messiah, they were abandoned by Heaven to the rage of their enemies, and finally escaped, a miserable remnant of unhappy fugitives, from the flame and the sword, which devoured their country and ruined its cities, and were dispersed amongst all nations, an astonishment and a by-word, as it was foretold they would be, to all succeeding generations, and a living evidence of the truth of those prophecies of which they are the subject. In the mean time the Christian revelation published at Jerusalem gradually extended its influence, until its authority was acknowledged by the Roman emperor, and throughout his whole dominions, and, finally, in all those European kingdoms into which the Roman empire was broken by its barbarous invaders; and thus was brought about, not by the violence of conquest, but by the peaceful triumph of a purer faith, one of the most extraordinary revolutions ever known in the manners, laws, institutions, and morals, of a large portion of the civilized world. In the middle ages, the deliverance of the holy city was the reigning delusion of that barbarous time; the war-cry was raised throughout all Europe against the infidels who dishonoured Jerusalem by their presence, and interrupted the pilgrimage to that holy place; the knights of Christendom, obedient to the call, assembled from all quarters round the banner of the cross; and vast armies were transported from Europe to Asia, to contend with the Mahommedans for the possession of the Holy Land. A long, bloody, and doubtful war terminated in the triumph of the infidels, and finally consigned the land of Palestine to their barbarous sway. A country which has been the scene of such various revolutions, and of so many marvellous events, in which the light of divine truth was first displayed, once so famed, and now so degraded, cannot fail to be regarded with deep interest in a liberal and enlightened age, affording, as it does, so many curious topics of discussion, and so wide a field of interesting inquiry. It has accordingly been resorted to, especially in modern times, by numerous travellers from Europe, whose works contain the most ample details concerning its natural features, its scenery, productions, animals, its antiquities, the manners of its inhabitants, and its present condition; and it is from the copious information contained in these works that the following narrative has been compiled.

Description. The tract of country known in modern times under the name of Palestine forms, for about 140 miles, from the thirty-first to the thirty-fourth degrees of north latitude, the eastern shore of the Mediterranean; whilst it is bounded on the east by the great Syrian desert, on the north the mountains of Libanus and Anti-Libanus form a natural boundary, and on the south it extends to the Arabian desert. It is 140 miles in length, as already mentioned, and about fifty in breadth; and is distinguished by the inequality of its surface, and by the varied scenery which it presents; "a land," says Sandys, with his usual force, "that flowed with milke and hony; in the middest, as it were, of the habitable world, and under a temperate clime; adorned with beautiful mountaines and luxurious vallies; the rockes producing excellent waters; and no part of it empty of delight or profit."[1] Along the sea-coast of Palestine, the country consists chiefly of fertile and extensive plains, from which the ground gradually rises by successive terraces or ridges, into the central range of mountains which intersect the country throughout its whole length, and which present, with intervening valleys of singular beauty, all the varieties of bold and rugged scenery, and often sterile and naked rocks. On the eastern declivity of these mountains the country is rich, diversified, and luxuriant; its lofty mountains and sloping hills covered with forests, the deep valleys watered by murmuring streams, and clothed with cultivation, or enlivened with the flocks and herds of the wandering Arabs.[2]

Those mountains which form the central chain of Judea run parallel, under various names, to the shore of the Mediterranean, being in general at the distance of twenty or twenty-four miles from the sea; Mount Libanus forms the summit, and they divide into two distinct chains, the greater on the west, which looks to the Mediterranean, and the lesser on the east, which bounds the plains of Damascus, and has received the appellation of Anti-Libanus. These ridges, throughout their whole extent, from the northern frontier of Palestine to the Dead Sea, are rugged and barren, and destitute of inhabitants. The country between these two chains is watered by the Jordan, which has its rise in the northern chain of the Libanus Mountains, and flows southward in the central valley through the Lakes of Hoole and Tiberias, until it terminates in the Dead Sea. The country has generally been divided into three regions, namely, Judea, which lies to the south, Samaria in the middle, and Galilee on the north; and to these may be added the region beyond the river Jordan, which, running along the whole length of the country, divides it into two distinct portions.

Judea proper contains the modern district of Gaza, and was formerly the central district of the ancient kingdom of Judah, of which it contained the metropolis. It comprehends the whole country from the Lake of Asphaltites to the sea, a space of about sixty or seventy miles in breadth. The soil consists of a sandy earth; and it rises in far-ascending terraces from the sea to the mountains. The country situated near the Mediterranean consists of low plains, that are both beautiful and fertile. The plain around Rama, says Dr Clarke, is as fertile as any part of the Holy Land. It resembles a continual garden; though at the time that this celebrated traveller passed through the country, cultivation had been neglected, owing to a dreadful plague by which it had been visited.[3] The sea-shore is lined with mastic trees, palms, and prickly pears. The plains, though neglected, are clothed with the richest vegetation; and Sandys describes the country on the coast between Jaffa and Gaza as luxuriant and beautiful. "We

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[1] See Relation of a Journey, in four books, containing a description of the Turkish Empire, Egypt, the Holy Land, &c. b. iii. p. 141.
[2] Travels in Palestine, by J. S. Buckingham, vol. ii. chap. xix. p. 118.
[3] Clarke's Travels in the Holy Land, vol. ii. chap. xviii. p. 637.

Palestine. past this day," he observes, "thorow the most pleasant and pregnant valley that ever eye beheld. On the right hand a ridge of mountains, whereon stands Hebron; on the left the Mediterranean Sea, bordered with continued hills, beset with variety of fruits, as they are for the most part of this day's journey. The champaign betweene about twenty miles over, full of flowrie hills ascending leisurely, and not much surmounting their ranker vallies, with groves of olives and other fruites dispersedly adorned."[1] In his journey southward along the coast to Rama and Joppa, he met with the same luxuriant country. The caravan, he mentions, lay in deep pastures, without controlment of the villagers; and descending through different valleys, having "divers orchards," towards the sea, he found a want of trees, but no part barren; and the country, he adds, "would prove more profitable if planted with vines and fruites." Higher up, the country becomes uneven and rocky, and so difficult is the road over rugged and pathless rocks, that though the journey between Jerusalem and Jaffa might be performed in thirteen hours, the distance not being more than forty miles, it generally occupies about a day and a half. The mountains consist of limestone, naked and barren, compared by Dr Clarke to the worst parts of the Apennines, which, however varied, have nothing either of the grand or the picturesque in their appearance. Yet however barren the hills in this district, the intervening valleys are remarkably fertile, and repay the labour of the cultivator by plentiful crops of tobacco, wheat, barley, Indian millet, melons, vines, olives, pumpkins, and cucumbers; while natural groves arise, consisting of the ever-green oak, the cypress, of andrachnes and turpentine trees; and the ground is covered with the rosemary, the cytasus, and the hyacinth. Of these valleys, that of Jeremiah and the Terebinthine Vale are remarkable; the latter famous in sacred history, as the scene of David's triumph over the Philistine. The entrance into this vale is over hills and rocks; the mountain is still seen on the one side, and the mountain on the other, exactly as it is described in holy writ; and the valley between them, and the very brook in which David "chose those five smooth stones," with one of which he smote the Philistine, and which has furnished drink to many a thirsty pilgrim, on his journey from Jaffa to Jerusalem.[2]

The vegetation of these mountains has been compared, for its richness, to that of Crete or Candia. Such is the spreading luxuriance of the forest, that travellers have reposed or dined under the shade of lemon-trees as large as one of the finest European oaks; and sycamores are to be seen, whose expanding foliage is sufficient to afford shelter to a band of twenty or thirty travellers, with their horses. Dr Clarke, in describing his journey to Jerusalem from the north, celebrates in the highest strains the beauty and fertility of the mountainous country through which he travelled. The road, he observes, was mountainous and rocky, and full of loose stones; yet the cultivation, he adds, is even marvellous, and affords one of the most striking examples of human industry that can be anywhere seen. "The limestone rocks," he continues, "and stony valleys of Judea, were entirely covered with plantations of figs, vines, and olive-trees; not a single spot was neglected. The hills, from their bases to their upmost summits, were covered with gardens; all of these were entirely free from weeds, and in the highest state of agricultural perfection. Even the sides of the most barren mountains had been rendered fertile by being divided into terraces, like steps rising one above another, whereon soil had been accumulated with astonishing labour. Amongst the standing crops we noticed millet, cotton, linseed, and tobacco, and occasionally small fields of barley. In places where the ground is subjected to irrigation, two crops are produced, one of wheat in May, and another of pulse in autumn."[3] In many districts fine wines are produced; that of St John, near Bethlehem, is said to be delicious. On the eastern declivity of the central mountains, as they decline into the valley of the Jordan near Jericho, the olives are produced of a large size, which give oil of the finest quality. The mulberry grows in straight rows in the open field, intermingled with the vine, which, hanging in festoons from the branches, presents a graceful appearance; and several of the fruit-trees are continually bearing flowers and fruit in all their stages. This luxuriant vegetation may occasionally languish or be burnt up during the extreme heats and droughts of summer; and at all seasons it is liable to be interrupted, and is only seen in detached spots in more lofty situations; but these exceptions to the general luxuriance of the scene may partly be ascribed to the heat and drought of the climate, and partly also to the indolence and general barbarism of the country. It is certain, that the more deeply we penetrate into these hills, the rugged nature of the scenery and the barrenness of the country increases, and, "as we approach the centre of Judea," says M. Chateaubriand, "the sides of the mountains enlarge, and assume an aspect at once more grand and barren; by little and little the vegetation languishes and dies; even mosses disappear; and a red and burning hue succeeds to the whiteness of the rocks. In the centre of the mountains there is an arid basin, enclosed on all sides with yellow pebble-covered summits, which afford a single opening to the east, through which the surface of the Dead Sea, and the distant hills of Arabia, present themselves to the eye. In the midst of this country of stones, encircled by a wall, we perceive extensive ruins, scanty cypresses, bushes of the aloe and prickly pear; some Arabian huts resembling white-washed sepulchres are spread over heaps of ruins. This spot is Jerusalem."[4] From the central chain of mountains in Judea a desert extends eastward to the Dead Sea, which is encompassed by two rugged chains of sterile hills. North-eastward, the large and fertile valley of the Jordan, called El Gor, has in all ages been celebrated for its rare and valuable productions. It is described by Josephus as the most fruitful country of Judea, in which numerous palm-trees flourished near the town of Jericho, besides the balsam-tree, which was considered as one of the great staples of the country, and the source of its wealth. All these fine productions, by which in ancient times the country was enriched, have now entirely disappeared; and in the vicinity of Jericho there is not a tree of any description, either of palm or balsam, and scarcely any verdure or bushes, to be seen about the site of this city, which is in ruins, and surrounded with desolation. This is ascribed, however, by Mr Buckingham, more to the neglect of agriculture, and of the ancient aqueducts which were constructed for the irrigation of the land, than to any change in the climate or soil. There are traces in many parts of Judea, of ancient and more extended, as well as more skilful cultivation, such as the remains of walls, which were built to support the soil on the declivities of the hills; also of cisterns, in which the rain-water was collected, and afterwards distributed in canals over the fields. In a hot and dry climate, and a rocky country, water is a main ingredient of fertility; and under an ardent sun a prodigious produce must have been extracted, by means of this artificial irrigation, from the thirsty soil. All the ancient accounts of Judea, accordingly, agree in describing it as a rich,

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[1] Sandys, lib. iii. p. 150.

[2] 1st Sam. xvii. 2, 3; Clarke's Travels in the Holy Land, vol. ii. chap. xviii. p. 625.

[3] Clarke's Travels in the Holy Land, vol. ii. p. 520.

[4] Travels in Palestine, vol. ii. chap. xvii. p. 70.

Palestine. productive, and well-cultivated country; and, under all the ruthless desolations of war and barbarism to which it has been exposed, it still retains the traces of careful cultivation. It still answers to its ancient character of a land flowing with milk and honey; the flocks of the Arabs finding here luxuriant pastures, and the wild bees still lodging in the holes of the rocks, where they lay up their stores of fragrant honey, that is seen flowing from them.

Every spot in Judea is consecrated by ancient recollections, and has been the scene of some great event in sacred history. Jerusalem, the capital, has been already described under its proper title, and is still a remarkable city, though declined from its ancient splendour. The other towns are Bethlehem, the birthplace of our Saviour, about six miles to the south of Jerusalem, renowned for its antiquity, and for the localities consecrated by the Redeemer's presence; and especially for an elegant church, on the supposed site of the sacred manger, enriched by offerings from all the nations in Europe. It contains from 1000 to 1500 inhabitants, mostly Christian. Hebron is still farther to the south, in a less arid country, with 1000 or 1200 inhabitants. This ancient city, the seat of David's kingdom before he took Zion from the Jebusites, is entirely in ruins. Gaza, famous as the scene of Samson's exploits, is situated near the sea-coast, on a hill in the midst of valleys, and these again surrounded with hills planted with all sorts of delicate fruits. It has now declined, like all the other cities in this country, from its ancient importance; the buildings, says Sandys,[1] being "mean, both for form and matter; some built of mud; among all, not any comely or convenient;" "yet," he continues, "even there some relicks left that testifie a better condition. For divers simple roofs are supported with goodly pillars of Parian marble; some plaine, some curiously carved. A number broken in pieces, do serve for thresholds, jambs of doors, and sides of windows, unto every beggarly cottage." Ten miles north of Gaza, on the sea-coast, stands Ascalon, celebrated during the Crusades, but now a place of no note. Azotus and Acheron, also on the coast, are places of no account; and Rama, about thirty miles north-west of Jerusalem (not the city to which the prophecy of Jeremiah applies, "In Rama was a voice heard," &c.), a magnificent city during the time of the Crusades, was found by Dr Clarke to exhibit one scene of ruin. This was no doubt partly occasioned by the plague, which had raged in Judea previous to his visit, but partly also to the general tendency to decline and ruin, which is seen throughout the whole country, from the indolence and barbarism of the inhabitants, and the oppressions to which they are exposed. The remarks of Sandys on the incongruities seen in the buildings at Gaza, of marble pillars in the meanest structures, apply generally to the towns throughout the Holy Land; all of which, however mean in their present appearance, bear the marks of former magnificence, and of a happier era. About ten miles to the west is situated the town of Joppa or Jaffa, which owes all its celebrity and importance to its being the port of Jerusalem, being one of the worst harbours in the Mediterranean. It was in ancient times the only port in Judea, to which, from Mount Libanus, were brought the materials for building the temple of Solomon, previous to their being transported by land to Jerusalem. To the north of Jerusalem, on the western slope of the central mountains as they decline into the valley of the Jordan, stood the ancient city of Jericho, now a scene of ruin, so that the site of this city is scarcely known; and Buckingham, one of the latest and most judicious as well as learned travellers, is of opinion that it has been fixed too near the river Jordan, at Rihhah. In a spot near to this he discovered heaps of ruins, the position of which seemed to agree more accurately with the site assigned to Jericho by Josephus than any other in the country. Palestine.

To the north of Judea lies the country of Samaria, which is the middle division of Palestine, and is now chiefly comprehended in the district of Naplous. This district of the country is, like Judea, mountainous in the interior; but along the sea-shore extends the plain of Sharon, from Mount Carmel on the north, with little interruption, according to Chateaubriand, into Judea, as far south along the shore as Gaza. But this space comprises, properly speaking, four distinct plains, separated from each other by ridges covered with loose stones. The soil of the plains in Samaria, though it is sandy in its nature, is of extreme fertility. It is covered during the spring with many varieties of luxuriant flowers, with white and red roses, with the narcissus, the lily white and yellow, and other beautiful and fragrant flowers and shrubs. Dr Clarke mentions, that he observed the *cactus ficus Indicus* growing to an enormous size, its gaudy blossoms making a splendid show, and concealing the thorns under them, that inflict severe and even dangerous wounds in this climate.[2] This fertile soil, according to Chateaubriand, languishing under the iron rod of Turkish despotism, produces nothing but thistles, dry and withered grass, mixed with inconsiderable plantations of cotton, millet, and grain. The condition of the country, no doubt, depends on the character of the Turkish pasha, to whose care it is committed; and the fairest promise of prosperity is frequently blighted by the misrule of a cruel and avaricious tyrant. Such was Djezzar Pasha, who ruled the pachalik of Acre at the time Dr Clarke visited the Holy Land; and who, by his cruelty and extortion, converted a fertile district into a desert. But the country that was under the milder rule of the pasha of Damascus bore an entirely different appearance; and Dr Clarke observes, "cultivated fields, gardens, and cheerful countenances, exhibited a striking contrast to the territories of Djezzar Pasha, where all was desolation, war, and gloominess." Mr Buckingham, however, ascribes this improved aspect of the country less to the influence of the government, than to the difference in the respective characters of the inhabitants of the hill country and the plain. At the later period, when he visited this district, it was ruled by the pasha of Acre, with benevolence and equity; and in the interval that had elapsed from the death of Djezzar, the country might have recovered from the effects of his violence and tyranny. The peasant will not cultivate where he is not sure of reaping the fruit, and, under the extortions of such a tyrant as Djezzar, the most fertile country may languish and decay. But the young corn and verdant spots, seen by Mr Buckingham, even to the mountain top, attest a flourishing state of agriculture scarcely consistent with the barbarous oppression of the former pasha, seeing that the effects of such tyranny are permanent; debasing, as it does, the habits of the people, and fostering an indolence and apathy that paves the way for the desolation of the country. Of the aspect of Samaria Mr Buckingham generally observes, that the face of the country so far resembles Judea, that both are composed of abrupt and rugged hills, differing essentially from the plains of Galilee. But the country of Palestine seems to deteriorate towards the south; it assumes a more bold, mountainous, and rugged appearance, and contains a much larger proportion of arid soil. Thus, in Judea, the hills are mostly completely bare, and it is only the narrow intervening valleys that are fertile; in Samaria, on the other hand, the hills are clothed to the summits with vegetation. These, adds this enterprising and judicious traveller, with the luxuriant valleys which they enclose, pre- Palestine.

[1] Lib. iii. p. 149.

[2] Travels in the Holy Land, vol. ii. chap. xv. p. 502.

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sent scenes of unbroken verdure in almost every point of view, which are delightfully variegated by the picturesque forms of the hills and vales themselves, enriched by the occasional sight of wood and water, in clusters of olive and other trees, and rills and torrents running among them.[1]

Samaria is divided from the northern province of Galilee by the river Kishon, or by the natural boundary of high ground, about six or eight miles nearly north and south, coming from the plain of Esdraelon, and terminating in the lofty promontory of Mount Carmel, famed of old for its beauty and luxuriant vegetation, and still bearing its native cedars and wild vines and olives, intermixed with brambles, as memorials of its ancient fertility and more careful cultivation, but, in general, consisting of barren and desolate rocks formed of a whitish stone, with flints imbedded in it. Sandys describes it as "rich in olives and vines, when husbanded, and abounding with several sorts of fruits and herbs both medicinal and fragrant, though now overgroune with woods and shrubs of sweet savour."[2] It has, towards the east, the fine plain watered by the Kishon, which flows past its base into the sea; and on the west, a narrower plain descending to the Mediterranean. It does not exceed 1500 feet in height. During the middle ages this mountain was filled with grottos, cut out of the rock, the abode of numerous monks, who, from this mountain, took the name of Carmelites. To each monastery a chapel and little garden were attached, so that the mountain was entirely covered with them. Mr Buckingham mentions that he saw several of these grottos, all small and rude; and a little below, he came to a sort of caravanserai, built before a fine cave, into which he entered, and found a well-hewn chamber cut entirely out of the rock, and squared with great care, being twenty paces long, twelve broad, and from fifteen to eighteen high. It forms a considerable halt for travellers, as it affords good shelter, and contains a cistern of excellent water. Pococke also mentions one of these grottos near the foot of the hill, "which," he adds, "is one of the finest I ever saw; it is like a grand saloon, and is about forty feet long, twenty wide, and fifteen high; it is cut out of the rock, and is now converted into a mosque."[3] The heights of Carmel enjoy a pure and enlivening atmosphere, while, in the interior, the sky is often obscured by fogs; and from the top of the mountain is an extensive prospect of the Mediterranean to the west, the snowy heights of Lebanon towering above the summits of the other mountains on the east, with Acre and the adjacent fertile plains. On the summit formerly stood the monastery which was for a long period the head-quarters of the Carmelite friars, and which is said to have been built near the spot where Elias offered up sacrifices. This monastery, which was not a fine building, is now entirely abandoned, and the monk who has charge of it lives in the town of Caypha, below. It was used as an hospital by the French during their campaign in Egypt, for which its retired and healthy situation, and its interior structure, well adapted it. It has been since greatly injured by the barbarous Turks; its altars have been stripped, and its roofs beaten in, though there still remains, for the edification of devout visitors, a small stone altar, in a grotto dedicated to St Elias, over which a coarse painting is seen of the prophet leaning on a wheel, with fire, and the other symbols of sacrifice beside him. There are few towns of any note in this once flourishing, but now comparatively desolate country. The chief town, however, Nablous or Napolose, Neapolis in the days of Herod, and the ancient Sichem, seems still to be, according to the account of Dr Clarke, the metropolis of a rich and extensive country, abounding in provisions, and all the necessaries of life. The white bread exposed for sale here on the streets is far superior to any seen elsewhere in the country. The inhabitants are industrious, and the manufactures of the town, of which soap is the principal, supply a very widely extended neighbourhood. The town is described as being embosomed in the most delightful and fragrant bowers; half concealed by rich gardens, and by stately trees collected into groves, all around the bold and beautiful valley in which it stands.[4]

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Sebaste, the ancient Samaria, the capital of the country, is now a village consisting of a few humble dwellings in the midst of magnificent ruins. This place was famous in the ancient Jewish history, and is mentioned as a city of importance by the Roman historians, and also by Josephus. It escaped the notice of Dr Clarke, though he passed near it, and he accordingly mistakes the castle of Sanhoor, or Santorni, for the site of this ancient metropolis. But its ruins are described at length by Buckingham. He saw the remains of one large street, consisting of eighty-three columns erect, and of others which had fallen, but all of them without capitals. On the eastern side of the hill on which the city stood, eight large and eight small columns are still standing, with many others lying near them, and blocks of stone and fallen pillars scattered on the adjacent ground; and in the humble walls of the houses that form the modern village, portions of sculptured blocks of stone are perceived, and even fragments of granite pillars, worked into the masonry, while other remains of former and more magnificent edifices are seen scattered around. The most conspicuous object that still remains at St Sebaste, is a large cathedral, now in ruins, attributed to the piety of the Empress St Helena. It is about a hundred feet in length by fifty in breadth, the northern wall quite plain; the eastern front semicircular, with three open and two closed windows, each contained in arches divided from each other by three Corinthian columns.[5] Most of the other towns here, as well as in Judea, exhibit marks of ruin, amid the memorials of ancient magnificence. The small village of Jennin, about twenty-five miles to the north, contains the ruins of a palace and of a mosque, with marble pillars, fountains, and even piazzas in a perfect state; and the ancient Cesarea, on the sea-coast, is now a scene of ruin, where fragments of fine marble pillars, and of ruined houses, are seen strewed on the ground, which is overgrown with briars and thistles, and the haunt of wild boars, which abound in the neighbouring plain.[6] Tortura is merely a small village on the coast, for large boats which are forced to put in here by stress of weather. It is generally supposed to be the ancient Dora.

To the north of Samaria is the district of Galilee, celebrated as the scene of many interesting incidents in sacred history. This province, though still hilly, contains a much greater proportion of champaign country than either Samaria or Judea; and its extensive plains have been celebrated by all travellers for their beauty and fertility. The delightful plain of Zabulon is described by Dr Clarke as being everywhere covered with spontaneous vegetation, flourishing in the wildest exuberance; as delightful as the rich vales in the south of the Crimea, and resembling the finest parts of Kent and Surrey.[7] The soil, although stony, is exceedingly rich, and well adapted for wheat, as well as for the olive, the vine, and other delicious fruits. The grapes excel so much both in size and flavour, that a cluster of them furnishes out the simple supper of a large family. Maundrell describes these plains as being eminently fertile, well watered, and containing every thing else that can render it pleasant and fertile;

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[1] Buckingham's Travels in Palestine, vol. ii. p. 390.
[2] Lib. iii. p. 203.
[3] Pococke's Travels, vol. ii. p. 56.
[4] Ibid vol. ii. p. 507.
[5] Pococke, vol. ii. p. 417.
[6] Ibid. p. 59.
[7] Travels in the Holy Land, vol. ii. chap. xiii. p. 400.

Palestine. but at the same time desolate for want of culture, and overgrown with weeds as high as the horses' backs.[1] Yet amidst this fertility there are tracts of limestone hills, which present one unbroken scene of sterility as far as the eye can reach. Buckingham mentions that he passed over a ridge of these barren hills in his approach to Nazareth from Acre, and that in most parts the hill was so steep and rugged, that he and his fellow-traveller were forced to descend it on foot. It is by these ridges, hills, or rocks, bare and barren, that the fertile plains of Palestine are separated from each other. Southward from Nazareth, which is situated on a range of rocky hills, extends the fertile and celebrated plain of Esdraelon, which is about two days' journey in length and twenty-one miles in breadth. This plain is covered with a fine red soil; it is the most fertile portion of all the land of Canaan; and though a solitude, lying waste, excepting only a few patches ploughed for cultivation towards its southern edge, it is one vast meadow, covered with the richest pasture, where formerly the tribe of Issachar rejoiced in their tents, and over which now range the wandering Arab tribes, around whose dark-brown tents the flocks are seen to gambol to the sound of the reed, which at night-fall recalls them to their home. The plain of Galilee is almost a continuation of the plain of Esdraelon, and appeared, according to the view that Buckingham had of it from Mount Tabor, to be highly cultivated throughout. The plain of Esdraelon, the plain of Megiddo, the Galilean plain, or the great plain as it is often called by way of distinction, has been from the most ancient times the arena on which hostile armies have contended for the dominion of Palestine. Here it was that Barak, descending with his ten thousand chariots from Mount Tabor, discomfited the host of Sisera; here it was that Josiah fought in disguise against Necho king of Egypt, and was slain by the arrows of the Egyptians; and here it was that the Romans arrayed their hostile squadrons for the conquest of the country. "It has been," observes Dr Clarke, "a chosen place of encampment in every contest carried on in this country, from the days of Nabuchadonozor, king of the Assyrians (in the history of whose war with Arphaxad it is mentioned as the great plain of Esdrelom), until the disastrous march of Napoleon Bonaparte from Egypt into Syria. Jews, Gentiles, Saracens, Christians, Frenchmen, Egyptians, Persians, Druses, Turks, and Arabs, warriors out of every nation under heaven, have pitched their tents upon the plain of Esdraelon, and have beheld the various banners of their nations wet with the dews of Thabor and Hermon."[2]

These two latter hills or mounts are often mentioned in sacred history. They are not so remarkable for their height as for their steep ascent from the adjacent ground. Mount Tabor, which rises abruptly from the plain of Esdraelon, is the last to the eastward of a range of four hills of a similar form, but less elevated, and less insulated from the neighbouring hills, and all having passes between them. Its height is 1000 feet, and it is a rounded hill of a globular shape, having its outlines smooth, and its breadth at the base greater than its height. It is clothed, for about one-fourth part upwards, with numerous luxuriant trees and thickets; and the top is an oval plain about a quarter of a mile long, covered with a fertile soil on the west, and having at its eastern end a mass of ruins, seemingly of churches, grottos, strong walls, and fortifications, all of some antiquity, though not of a remote age. These remains here, as in every other part of the Holy Land, afford subjects for monkish fables; and in this manner every remarkable spot in the country is converted into the scene of some memorable incident in holy writ. Here are three grottos, pointed out as the remains of the three tabernacles proposed to be erected by Peter at the time of the transfiguration. In one of these grottos there is a square stone used as an altar; and the night of the sixth August is held as a great festival by all the friars from the convent of St Nazareth, who come with their banners and their host to say mass, accompanied by the catholics in the neighbourhood, and spend the night in festivity, lighting huge bonfires, the wood on the mountains being taken for fuel, and its southern side being in consequence nearly denuded of all the trees which formerly clothed it. There are other scriptural references to Mount Tabor. It was towards this mount that Barak was commanded to draw his forces when he went to meet the host of Sisera; and it seems to have been, in after ages, considered as a good position, as it was, during the invasion of Judea by the Romans, encompassed with a wall, and occupied as a military post when the Jews were besieged by Placidus, the lieutenant of Vespasian. There is also a vague tradition of a city built on the top, which sustained a five years' siege; and it is certain that it was formerly a place of great strength; and when it lost this warlike character, it became a sanctuary; so that ancient remains, religious as well as warlike, now mingle on its summit in one common ruin. Hermon, about six miles distant, rises from that range of hills which bounds the great plain of Esdraelon on the south. Its lofty peak condenses the vapours of the atmosphere, which descend in copious dews, and produce the most luxuriant vegetation, while the surrounding country is parched with drought; so that this renowned mount completely answers to all the scriptural allusions concerning its fertility and verdure, and the refreshing dews by which it is watered, and which in this country are so profuse as to compensate the long drought, and supply the place of rain. Palestine.

Galilee is remarkable as the scene of our Saviour's first preaching and miracles, and its towns and villages are associated with many interesting events of Scripture history. Nazareth contains about 2000 inhabitants, consisting of Catholic Christians, Maronites, Mahommedans, and schismatic Greeks. The Maronite church is built over a grotto, held sacred as the supposed scene of the angel's annunciation to Mary, of her conception and birth of the Saviour. There is another grotto, with two red granite pillars about two feet in diameter at its entrance, one of which is said to mark the spot where the virgin rested, and the other where the angel stood when he intimated to Mary her favour with the Lord. The grotto, though only about eight feet in height, still remains in its original roughness, the roof being slightly arched. Every spot here has its absurd legend, the credit of which the friars are interested to maintain. The chimney of the hearth is shown on which Mary warmed the food for her infant son, and where she baked cakes for her husband; also the apartment in which her son lived in subjection to his parents; and Buckingham is of opinion that this last tradition is nowise improbable, as excavated buildings in the side of steep hills, such as the one he describes, are more secure and more permanent than others, and as it is known that Joseph and Mary dwelt in this place, where they reared their son. There is no evidence however to prove, that though they dwelt at Nazareth, this house was their residence, farther than the most vague tradition; and Dr Clarke seems to consider, with much appearance of reason, all these legends as inventions of the superstitious and ignorant monks, in order to maintain the reputation of these holy places. The synagogue in which Christ read and expounded the prophet Esaias is shown within the town; and, more than a mile distant to the southward, the precipice is pointed out from which the Jews, offended with his doctrine, would

[1] Maundrell, p. 52.

[2] Travels in the Holy Land, chap. xv. p. 499.

Palestine. have cast him headlong. Not many miles to the east of Nazareth is Cana of Galilee, where our Saviour performed his first miracle of changing the water into wine; and about a quarter of a mile from the village there is a delicious spring of clear water, whence the village is supplied and whence was drawn the water which was made wine. Cana is a small village, containing the ruins of a church, erected, according to tradition, on the spot where the marriage-feast of Cana was held; and among these ruins Dr Clarke remarked, that there were large massy stone waterpots, the vessels commonly in use in the country, and answering the description of those used of old by the Jews. About three miles from Cana is the village of Turan, in a field, where they assert that the disciples plucked the ears of corn on the Sabbath-day, and from which the pious devotees from Italy still gather the stalks of wheat as relics to carry back to their own country. From nine to twelve miles north-north-east stands the town of Tiberias, along the edge of the lake of that name. It has all the showy appearance of a Turkish citadel from without, which is sadly contrasted with its wretchedness within; it is supposed to be the Chemeroth of the Hebrews. No antiquities now remain except an ancient church, constructed during the fourth century. Two or three miles southward from the town are warm baths, that have been long in great repute. A small and mean building has been erected over them by the Mahommedans. Extensive ruins are scattered around, supposed to be the remains of Roman edifices. Of the other ancient cities of Galilee, Capernaum, now called Talherom or Tel Hoom, situated about ten miles in a north-easterly direction from the lake of Tiberias, formerly a place of importance, is now reduced to a station for the wandering Arabs. As is the case, however, with the other towns of Judea, the memorials of former magnificence lie scattered around. The traces of a magnificent building are still to be seen, though its ruin is so complete that its character can no longer be ascertained. The whole space within its extensive walls is covered with blocks of sculptured stone, in friezes, cornices, and mouldings. Bethsaida, also near the Lake of Tiberias, and which was enlarged and embellished by Herod, is so entirely ruined that no traces remain to mark out the site of its walls, or of its temples or palaces. Acre, the Accho of the Scriptures, and one of the strongholds from which the Israelites were not able to dislodge the Canaanites, is celebrated for the bloody conflicts of which it was the scene during the crusading wars, and in modern times for its gallant defence against the victorious legions of Bonaparte. It is situated on the extremity of a plain, at the bottom of the bay of Acre, formed by the promontory of Mount Carmel on the south-west, and the skirts of the plain itself on the north-east, and about ten miles across. A particular description of Acre will be found under its proper title; and we may only add, that Mr Buckingham, in his visit to this town, thought that he discovered the Canaanitish remains of the ancient city of Accho. The workmen were sinking a ditch to surround the outer wall, to the depth of twenty feet below the level of the soil; by which the foundations of very old buildings were exposed to view, constructed of such materials as marked beyond a doubt a very high antiquity; being a "highly burned brick, with a mixture of cement and sand, as well as small portions of stone in some parts, the whole so firmly bound together by age, and the strongly adhesive power of the cement, as to form one solid mass."[1]

Mountains. Judea is intersected throughout its whole length by a ridge of mountains, from which other and lesser branches diverge, and overspread the whole country. These mountains are a prolongation of the Syrian chain, which begins on the south of Antioch, with the huge peak of Caprus, Palestine. shooting up to the heavens, its needle-like point encircled with forests. This chain, on entering Judea, follows the shores of the Mediterranean, from which it is not above twenty or thirty miles distant. Mount Libanus, which is within the line of perpetual snow, is its highest summit. This ridge divides itself into two, namely, that of Lebanon, which overlooks the Mediterranean, and another chain, called Anti-Libanus, which looks eastward over the Syrian desert. This chain must be of very great height, as its snowy summits were seen by Dr Clarke in his journey from Nazareth to Tiberias, towering beyond a series of intervening mountains with unspeakable greatness. He considered these mountains as part of the chain of Lebanon, though the Arabs who accompanied him described them as part of the Anti-Libanus chain, near Damascus. "The summit," says Dr Clarke, "was so lofty that the snow entirely covered the upper part of it; not lying in patches, as I have seen it during summer upon the tops of very elevated mountains, as on Bennevis in Scotland, but investing all the higher parts with that perfect white and smooth velvet-like appearance which snow only exhibits when it is very deep; a striking spectacle in such a climate, where the beholder, seeking protection from a burning sun, considers the firmament to be on fire."[2] Lebanon is still covered with tall cedars, and in ascending its sloping sides, all the varieties of a European climate are experienced, with a corresponding variety of vegetable produce. The ground is enriched with thousands of rare plants, and beautiful and fragrant flowers; the primrose of Libanus, the mountain amaryllis, mingling their brilliant hues with the verdure of the birch-leaved cherry. Not only the summits, but the higher valleys, are covered with perpetual snow. At a lower level, a perennial verdure is maintained, by the humidity and coolness of the atmosphere, and the good quality of the soil; and it is pleasing to remark, in these higher regions, where industry is here less harassed by the predatory inroads of the Arabs, that the country exhibits a flourishing appearance; and we here behold those ingeniously contrived terraces, which preserve the fertile earth; well planted vineyards, which produce the finest wines; fields of wheat; plantations of cotton, of olives, and of mulberries, which in the midst of rocky steeps, present the pleasing picture of successful industry. These mountains are chiefly composed of limestone rocks, and abound in those ores which are common in Palestine, and are characteristic of that formation.

Rivers and lakes. The deep ravines of these mountains are watered by numerous streams, which arise on all sides in great abundance. But the principal river of Palestine is the Jordan, which has its rise in the range of Libanus, and, running from north to south, intersects the whole country of Palestine. It forms the small lake of Hoole, and enters the great lake called the Sea of Tiberias, from the southern extremity of which it again issues. Flowing southward through an extensive plain, it passes Jericho to the east, and falls into the Dead Sea or Lake of Asphaltites. The Lake of Tiberias at Gennesareth is twelve or sixteen miles in length from north to south, and in breadth seems to be from six to nine miles. The surrounding scenery is of no common grandeur, the lake is surrounded by precipitous hills, which shelter it from the tempest. Yet it is occasionally liable to dangerous storms, because, when the wind blows violently, it strikes down perpendicularly on the surface, and ploughs it up into the most frightful inequalities. It was in one of these storms that the disciples of our Saviour, who had embarked in one of the small vessels that traverse the lake, were in danger of perishing, when they saw Jesus, about the fourth watch of the night, walking up-

[1] Travels in Palestine, vol. i. p. 116.

[2] Travels in the Holy Land, vol. ii. chap. xiv. p. 456.

Palestine. on the waves. The barrenness of the surrounding mountains, and the total absence of wood, give an aspect of dulness to the scenery; and this impression is heightened by the dead calm and the silence which reigns over the wide expanse of its waters, where not a boat or vessel of any kind is to be seen. The Lake Asphaltites, or the Dead Sea, in which the Jordan terminates, is sixty or seventy miles in length by ten or twelve in breadth. This lake is slightly curved in the form of a bow, sunk between two ranges of mountains, which have no resemblance of form, nor any common properties of soil. It is surrounded, like the Lake of Tiberias, by lofty and barren mountains; and is also remarkable for the death-like stillness of its waters. The surrounding scenery is represented as being in the highest degree grand and awful; and its desolate aspect is well adapted to the marvellous tales which are told of its malignant influence. The waters of this lake were formerly believed to be destructive of animal life, so that no fishes could live in them; that birds flying across were killed by the pestilential exhalations from its surface; that heavy bodies were buoyed up by the specific gravity of its waters; and, finally, a singular species of fruit, called the apples of Sodom, was said to be produced on its shores, which was beautiful to the eyes, but bitter to the taste, and full of ashes or dust within. All these fables have, however, disappeared before the rational inquiries of modern travellers. It is now known, that the supposed deadly waters of this lake swarm with myriads of fishes; that flocks of swallows are seen constantly skimming along its surface; that the absence of other birds arises from the want of vegetable food in the adjacent rocks or barren plains; and that the mysterious fruit found on its shores is as natural as any other vegetable production. Respecting this fruit various theories have prevailed. Tacitus and Josephus are the first authors who mention its singular properties; other authors, describing this fruit as an emblem of worldly pleasures, fair without, but full of rottenness within, gave a romantic and fabulous cast to the story; so that subsequent travellers, such as Pococke and Shaw, doubted the existence of any such production. Hasselquist, however, the botanist, described it as the fruit of the *Solanum melongena*, found in abundance near the Dead Sea, of which the fruit, when attacked, turns to dust, the skin only remaining entire, and of a beautiful colour. M. Seetzen thought that he discovered the fruit called the apple of Sodom, which contained within a sort of cotton resembling silk; while Chateaubriand describes it as growing on a shrub which he found everywhere within three leagues of the mouth of the Jordan. Before it is ripe it is filled with a corrosive and saline juice; and when dried it contains a blackish seed, that may be compared to ashes, and which has the taste of a bitter powder.[1] The water of this lake is of greater specific gravity than any other known, and is remarkably buoyant. Its specific gravity is 1·211, while that of fresh water is 1000. It is impregnated with a mixture of different saline substances; such as lime, magnesia, soda, sulphate of lime; and the taste is a compound of salt and bitter, extremely offensive.

Plain of Jordan. The valley of the Jordan is a marked feature in the scenery of Judea. It is situated between the lofty and central range of mountains on the west, which rise to the height of from 1500 to 2000 feet, and the range of the Arabian mountains on the east, the height of which does not exceed 1000 feet. Nothing can exceed the forbidden aspect of these western hills; not a blade of verdure is to be seen over their whole extent, nor any sound to be heard; the eastern range is equally barren, except some little dells near the plain, where the rains, being collected, favour vegetation. This is said to be the wilderness in which the Saviour dwelt with wild beasts, while angels ministered to him; and it certainly Palestine. forms, according to the accounts of all travellers, a most appropriate scene for such an incident. In the mountains are many grottos of the early anchorites, in long ranges, and consisting of separate chambers, now entirely deserted. Here Mr Buckingham observed the remains of a fine Roman aqueduct, consisting of at least twenty arches, and leading from the foot of the mountains, in a direction from west to east, into the valley of Jordan. Here also he fixed the site of the cities of Bethel and Ai, describing the nature of the ground as being extremely favourable for the ambush by which these cities were destroyed. The great plain of Jordan, hemmed in on both sides by mountains, fills up the whole space between the Lake of Tiberias and the Dead Sea, and it is about fifteen miles in breadth. This plain is in some parts unfertile, the soil being covered with a saline incrustation, and having small heaps of a white powder like sulphur scattered at intervals over its surface; in other parts it is more fertile, being covered with a carpet of green. The country that lies beyond the Arabian mountains on the east of the valley of Jordan, is a sort of table-land, though still diversified in its surface: it is a fine country, of an entirely different aspect from the bare mountains of Judea, and rivalling in fertility and picturesque beauty the celebrated plains of Zabulon and Esdraelon in Galilee and Samaria. Mr Buckingham describes with equal delight and admiration the varied beauties of this romantic region, the Decapolis of the Romans, the seat of ten renowned cities, famed for wealth and refinement, but now a scene of desolation, over which the wild Arab ranges with his flocks in quest of pasture or of prey. The country, according to the account of this traveller, is of extraordinary richness, abounding in the most beautiful prospects of thick forests, verdant slopes, and extensive plains. The landscape alone varied at every turn, and gave new beauties from every different point of view. "The general face of this region," he adds, "improved as we advanced farther into it; and every new direction of our path opened upon us views which surprised and charmed us by their grandeur and their beauty. Lofty mountains gave an outline of the most magnificent character; flowing beds of secondary hills softened the romantic wildness of the picture; gentle slopes, clothed with wood, gave a rich variety of tints hardly to be imitated by the pencil; deep valleys, filled with murmuring streams and verdant meadows, offered all the luxuriance of cultivation; and herds and flocks gave life and animation to scenes as grand, as beautiful, and as highly picturesque, as the genius or taste of a Claude could either invent or desire." This district of Bothin, or the ancient Battanea, is distinguished by numerous caverns hollowed out of the calcareous mountains, which served formerly as the abodes of the ancient inhabitants, and now of the wandering Arabs. It was here that a modern traveller, Dr Seetzen, discovered, in 1816, the ruins of Djerash, the ancient Gerasa, where temples, superb amphitheatres of marble, and hundreds of columns, are still seen, among other splendid remains of its ancient grandeur. The finest object which he met with was a long street bordered on each side with a row of Corinthian columns of marble, and terminating in a semicircular open space surrounded with sixty Ionic columns. This city occupied nearly a square about a mile in length, facing the four cardinal points. It stood on the slopes of two opposite hills. The whole surface of the western hill is covered with temples, theatres, colonnades, and ornamental architecture. The plan of the city was distinctly traced by Mr Buckingham, amid its splendid ruins; the main street intersected by two other streets at right angles,

[1] Chateaubriand, vol. i. p. 413. "J'ai cueilli," he observes, "une démi-douzaine de ces fruits; j'en possède encore quatre dessechés, bien conservés, et qui peuvent mériter l'attention des naturalistes."

Palestine. in which the Ionic and Corinthian orders prevail. A detailed description of the temple, the theatre, and the other ornamental buildings which are seen at this place, and of which, though in ruin, a large proportion still remains, would be inconsistent with our present limits; and the reader is therefore referred to the work of Mr Buckingham, which contains ample details on the subject.[1] Amman, the ancient Philadelphia, one of the principal cities of Decapolis, presents also very splendid ruins; and to the south, on the eastern shore of the Dead Sea, is found the bleak, barren, and mountainous district of Carac, where are the ruins of Rabboth-Moab, the ancient capital, and formerly a populous and an important place. Farther to the north are found the countries called by the moderns Haouran and Dschaulan, little known until, of late years, they were explored by the travellers Dr Seetzen and Burckhardt. They consist of a vast plain of table-land, stretching southward from Damascus, not watered by any great river, yet rendered fertile by the industry of the inhabitants, who collect the rain-water into ponds for the purpose of irrigation, and thus contrive to raise large crops of grain. Of these countries Haouran is the most celebrated for its luxuriant harvests of wheat; and the undulations of the ripened grain on its extensive fields have been compared to the rolling waves of the ocean. Many hummocks are seen scattered over the plain, the sites generally of deserted villages. All these hummocks, and every stone found in the field, all the building stones, and the whole mountains of Haouran, consist of basalt; and the houses being entirely built of this stone, even to the door-posts, present rather a sombre appearance.

Vegetable produce. The vegetable products of Palestine have been partly described in the preceding sketch of the country. On the fertile plains of Galilee and Samaria, as well as in the valleys among the hills, are produced abundant crops of grain, namely, wheat, rye, barley, Indian millet, also cotton, linseed, and tobacco, while the limestone rocks and stony valleys are clothed with plantations of the fig, the vine, and the olive trees; pumpkins, cucumbers, and melons are also produced in great abundance and perfection. The water-melons, especially, which are produced at Joppa, are celebrated all over the Levant, and are delicious. They are also found at Damietta in Egypt, and seem to owe their flavour to the peculiar soil of these two places; for when they are transplanted, though they be cultivated in the same manner, they lose their exquisite flavour, and quickly degenerate.[2] The orange tree, dates, and bananas, and other delicate fruits, also flourish in Palestine. Sesamum abounds, which affords oil; and the doura, a species of grain similar to that in Egypt. Maize thrives in light soils, and rice on marshy grounds. Indigo grows wild on the banks of the Jordan, and with care and industry might be brought to perfection. The white mulberry forms the riches of the mountain country of the Druses, by means of the beautiful silks which are obtained from it; and the grapes, that grow especially on the mountains of Lebanon, yield red and white wines, which rival those of France or Portugal. Jaffa boasts her lemons and her water-melons, and Gama possesses both the dates of Mecca and the pomegranates of Algiers. Sugar is cultivated in the adjoining country of Syria; and there is little doubt that it might be transplanted with success to the equally congenial soil of Palestine. The coffee shrub from Arabia might also be cultivated with equal success. Palestine produces a variety of forest trees. The sea-shore is lined with mastic trees, palms, and prickly pears. Higher up, the sycamore tree repays the labour of the cultivator, and natural groves arise, of oaks, cypresses, andraches, and turpentine trees. The oaks of Bashan still remain, and Lebanon is crowned with its stately cedars. Palestine. The ground is covered with shrubs and fragrant flowers; so that the vegetation on the mountains has been compared to that of Ida in Crete.[3] In the desert and rocky places are found scanty cypresses, bushes of the aloe and prickly pear, and a few other thorny shrubs.

Minerals. Owing to the gross ignorance and the wandering and predatory habits of the inhabitants of Palestine, no inquiries have ever been made into the mineral produce of the country; though there is little doubt but the mountains of Lebanon, if they were explored, would yield mineral ores, and other valuable substances. Rich iron mines are said to exist in the country of the Druses, but whether they are worked with any effect does not seem to be known. Nitre is here abundant, but alum and vitriols are less frequent. The only metal found is iron. The mountains along the shores of the Dead Sea consist of granite; and the country in many parts exhibits traces of a volcanic origin. Mr Buckingham, while crossing the river Hieromax in his journey to Nazareth, observed that the dark masses of rock over which it took its course resembled a stream of cooled lava. The stones of its bed were porous, and on the ground were small patches of sulphur in many places; and he was of opinion that all these, together with the hot springs he had visited, the lakes of Cesarea and Tiberias, the sulphureous and unfertile nature of the plain of Jericho in many parts, and the whole phenomena of the Dead Sea, namely, the bitumen, the lavas, and the pumice, which continue to be thrown ashore by its waves, were sufficient indications of volcanic fires, perhaps on the whole range of the long valley, from near the sources of the Jordan, to beyond the point of its issue in the great Lake of Asphaltites. The hot springs mentioned above were seen and examined by Mr Buckingham. One on the banks of the Hieromax emitted a highly sulphureous odour, and its heat was painful if the hand was immersed in its water beyond a few seconds. In the baths near Tiberias the water had also a slightly sulphureous taste, and was of a light-green colour; though the heat was not much greater than that of the atmosphere, the thermometer, which was at eighty-four degrees, rising when immersed in the water only to eighty-six. The hill from which these baths are supplied consists of a black and brittle sulphureous stone, which is found in the neighbourhood, as well as on the shores of the Dead Sea, and in other parts of the valley in which it is situated. Here also is found a species of limestone called the fetid, and emitting a highly offensive smell. The bitumen that is seen on the shores of this lake, or is collected in the middle of it by boats and rafts, rises from the bottom and floats on the surface.

Climate. The climate of Palestine varies in different districts, according to the locality and elevation of the ground; and the plains on the sea-shore are subjected to intense heat, accompanied with heavy rains. The plains in the interior, and especially those near Arabia, are subject to drought and to scorching heat; while the Libanus range of mountains, covered with everlasting snow, diffuse a refreshing coolness all around. In these elevated regions the winter, lasting from November to March, is sharp and rigorous. Heavy falls of snow take place every year, and cover the ground to the depth of several feet for months together. The spring and the autumn are mild and agreeable, and the summer is not oppressive. In the plains the heats during summer are most excessive. Dr Clarke mentions, that on the 6th July, at twelve o'clock, Fahrenheit's thermometer, in a gloomy recess under ground, perfectly shaded, stood at 100 degrees. In the course of the same month

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[1] Travels in Palestine, vol. ii. chap. xxi.

[2] Richardson's Travels along the Mediterranean, vol. ii. p. 268.

[3] Malte-Brun, vol. ii. p. 150.

Palestine. the thermometer, before noon, in the shadiest place that could be found, stood at 102. During this excessive heat all nature seems to droop, and every animal seeks the shade. But the chameleon, the lizard, the serpent, and all sorts of beetles, bask in the sun, even at noon, on rocks and sandy places, and seem to rejoice under his scorching rays. These overpowering heats commence as soon as the sun has passed the equator, and continue till October. During this season the simoom, or the south wind of the desert, is frequently experienced. In July, Dr Clarke felt the parching influence of this unhealthy wind, which pervaded all places alike, coming as if from a furnace, and producing a feeling of suffocation. He himself was affected with giddiness and burning thirst from the fierce blast; afterwards with headach, frequent fits of shivering; and, finally, with violent fever. These winds continue from one to three days. Easterly gales prevail during the spring and part of the summer. In June variable breezes commence, and blow from all points in the course of a single day. During the autumnal equinox, the north-west, which is a clear, dry, and sharp wind, begins to blow with strength. In November the wind shifts to the west and south-west, which invariably brings on heavy rains; the west wind being called by the Arabs the father of rain. Palestine, from its northern latitude, is without the range of the tropical rains; and has in their stead the early and the latter rains in spring and autumn. These are generally copious, though they sometimes fail, when the country is burnt up with drought. The heaviest rains fall generally in December, which in January spread a covering of verdure over the whole country. But when Mr Buckingham was travelling in Palestine, drought had prevailed from October to January, with only an interval of two or three days' rain; and the whole country had a dry and parched appearance. The winter is so mild in the plains and along the seashore, that orange trees, dates, and bananas, and other delicate fruits, flourish in the open field. It is during this season that, contrary to what is observed in other countries, storms of thunder and lightning generally take place, accompanied by heavy showers of rain or large hail-stones. Maundrell mentions, that he met with a severe storm of heavy rain, with terrible lightning and thunder, on the 3d of March, in his journey from Aleppo to Jerusalem.[1]

Animals. An enumeration of the animals which belong to Palestine is given in the sacred volume; but the particular animal to which the Hebrew name applies is often a question among the learned, and hence the zoology of this country may perhaps be best illustrated from the descriptions of modern travellers. Its domestic animals are chiefly those of Europe, with the addition of the buffalo and the camel. Its wild animals are the ounce or the panther, the hyena, the jackall, and, according to some, lions have been seen among the rushes and thickets on the banks of the Jordan. The gazelle or the antelope, supposed to be the roebuck or tzebi of the Hebrews, is seen in flocks bounding over the grassy plains, and is often hunted by the Arabs. The wild boar is also an object of the chase; and on a plain covered with bushes in the vicinity of Mount Carmel, Mr Buckingham saw a party of soldiers in pursuit of a large wild black boar, which still fled from the horsemen, though wounded and streaming with blood. Among the wild and solitary mountains the fallow-deer is to be found; also the wild goat, with horns bending over the back, a foot or fifteen inches in length; and the wild ass, which is found in all the most desolate parts of Asia. Of the ornithology of Palestine we have no very accurate or scientific account. There is, indeed, in the law of Moses an enumeration of the clean and the unclean birds; but great difficulties occur in translating the Hebrew nomenclature into modern language. The most remarkable of the feathered race may, however, be mentioned, such as the eagle, the vulture with the feathered ring round the neck, and from four to five feet in height,[2] the ostrich, the hawk, the kite, the raven, &c.; and of sea-birds, the pelican, the stork, the cormorant, &c. Serpents and other reptiles, quickened into mischievous activity by the heat of the climate, are common in Palestine; and Dr Clarke mentions, that in passing through the streets of Nazareth he perceived a woman issuing hastily from a house, carrying a cradle containing an infant, and frantic with rage and grief. Returning immediately, she was seen beating something violently on the ground, which proved to be an enormous serpent, which she found near her infant, and which she quickly despatched, filling the air all the while with the most piercing shrieks. Dr Clarke does not describe to what species this serpent belonged. The gecko is a deadly reptile of the lizard tribe, resembling a chameleon, his head triangular and large, the eyes large, the tongue flat, rounded at the end, and covered with small scales, and the teeth so sharp as to make an impression on steel. It is of a green colour, spotted with brilliant red, and its bite kills in a few hours. The viper is remarkable for the malignity of its poison. It is about the thickness of a man's arm, about two feet long, and beautifully variegated with yellow and brown spots. The black serpent is about a cubit in length, and the thickness of a man's finger. Its bite is not incurable. The cerastes, or horned viper, described by Bruce, is also found in Palestine; and the asp, the well-known cobra de capello. The former moves with great rapidity backwards or forwards, and has all the cunning of the serpent brood, creeping silently, and with its head averted, towards the object of its attack, until within a sufficient distance for the fatal spring. This is supposed to be the adder of the Scriptures. Other species of serpents are enumerated; and to this frightful catalogue is added the scorpion, whose bite, though not deadly, causes serious illness and pain. The country is occasionally visited by swarms of locusts, in such numbers that they darken the air, and consume grass, foliage, and every description of vegetation.

Popula-tion. Palestine has been so often conquered and occupied by foreigners, that its population now presents a mixture of different races, so that it is not easy to say to what class the inhabitants chiefly belong. The Turks, the last conquerors of the country, are numerous, and occupy all the civil and military posts; but the Greek Christians are also a numerous body, and form a great proportion of the inhabitants of the towns. There are, besides, the Druses and the Maronites; the European Christians, Jews, Armenians, and Nestorians; and the wandering Arabs, who range over the desert plains. The Greek Christians enjoy the most ample toleration; and there is scarcely any considerable city without one or more convents. The Christians are generally more active in trade than the Mahommedans, and they have gradually increased in numbers and in wealth. In some places they mingle more freely with the Moslems than in the more civilized parts of Syria, to which the power of the pashas extends; and enjoy a community of privileges, without any enforcement of those odious distinctions of dress, tribute, and name, imposed by the Turkish oppressor, as the badge of servitude. It was asserted to Mr Buckingham, that there are Bedouin Arabs dwelling in tents, who have been converted to the Christian faith, and live in the regular exercise of that religion. But of those remarkable converts he could obtain no account. These Christians, however, profane their creed by an admixture of superstitious rites; and Dr Clarke, as well as other travellers, gave them no credit for the morality of

[1] Maundrell's Journey, p. 9.

[2] Buckingham's Travels in Palestine, vol. i. p. 189.

Palestine. their lives. The contentions of the different Christian sects in Jerusalem, for admission into the temple, are often stained with blood; and many other examples are given of their gross superstition, and ignorance of the first principles of the Christian faith. After observing, that in Jerusalem there are sects of every denomination, and perhaps of almost every religion upon earth, Dr Clarke observes, "if we add, that, under the name of Christianity, every degrading superstition and profane rite equally remote from the enlightened tenets of the gospel and the dignity of human nature are professed and tolerated, we shall afford a true picture of the state of society in this country."[1] The Druses, who reside in the mountains of Libanus, are a singular sect, whose tenets appear to incline to deism, as they profess to regard all modes of faith with equal indifference. Their number is estimated at 120,000. They are valiant, and faithful to their emirs or chiefs, and rigidly adhere to the barbarous principle of revenging blood by blood. Of the doctrines, practices, and manners of this singular sect, no very accurate account has ever been obtained. Dr Clarke, who conversed with one of them respecting their peculiar tenets, says that they worship Jonas the prophet, and Mahommed. Their rites are pagan, and they pay the highest adoration to a calf. Those with whom he conversed confessed that the pantheon of the Druses admitted indiscriminately, as objects of adoration, every deity or idol that had been worshipped by Heathens, Jews, Christians, or Mahommedans; all the prophets, especially Isaiah and Jeremiah, as well as Jesus and Mahommed; that every evening the okhals or priests set up a molten idol in the form of a calf, before which persons of both sexes make their prostrations; and then he adds, that a promiscuous intercourse takes place between the sexes. It seems doubtful, however, whether this stain of licentiousness can attach to the whole sect, as it is inconsistent with those habits of strict probity and industry, and that love of independence, which they are admitted on all hands to possess. The same traveller afterwards adds, that it is not true that they betray any inclination to Mahommedanism, because they show every mark of hatred and contempt to the Moslems, while they behave with benevolence and kindness to the Christians, whose religion they respect. Their language is Arabic; in every thing else they are a distinct race of men. From their physiognomy alone Dr Clarke was able to select one of the Druses from a whole company of Arabs. "A certain nobleness and dignity of feature," he adds, "a marked elevation of countenance, a superior deportment, always distinguished them, accompanied by openness, sincerity, and very engaging manners."[2] Although Mount Libanus be the chief residence of this sect, individuals are scattered over every part of the Holy Land. The Maronites, to the north of the country of the Druses, are inhabitants of the mountains of Syria, though great numbers of them dwell in Palestine. The inhabitants of Sephaury are chiefly Maronites, and they are found in Nazareth, along with Greeks and Catholics, as well as in other cities of Galilee. They are connected with the church of Rome, though they maintain the legality of marriage among the priesthood. Their patriarch resides at Karobin, in Syria, which may be considered as their capital. They are industrious cultivators; the common people, and also the sheiks, living economically, says Malte-Brun, under a rustic roof, and receiving with hospitality and kindness every Christian traveller into the bosom of their families. The Jews are found in considerable numbers throughout Palestine. Of late years they have greatly increased, though they are a degraded race, not only tyrannized and trampled on by the Turks, but exposed to every species of cruel indignity. Mr Buckingham mentions, that while he was travelling from Nazareth to Tiberias, he met a party of Jews mounted on asses, who, considering him, from his Turkish dress and white turban, to be a Mahommedan, all dismounted and passed by on foot. "These persecuted people," he adds, "are held in such opprobrium here, that it is forbidden to them to pass a Mussulman mounted, while Christians are suffered to do so either on mules or asses, though to them it is also forbidden to ride on horseback without the express permission of the pasha." The Bedouin Arabs wander in considerable numbers over the desert plains of Palestine. In habits, dress, and manners they very nearly resemble their brethren of the Arabian deserts. They subsist by pasture and robbery, attacking and murdering, without remorse, the defenceless traveller who may fall in their way. The open country is, in this manner, a scene of rapine and violence. The husbandman who sows is never sure of reaping the harvest; his cattle, his corn, may be swept away in a moment by an irruption of Arab cavalry from the eastern deserts. The robbery of the way-faring man when he fell among thieves in his journey among the mountains of Jericho, and the surprise, by three bands of plunderers, of Job's sons when their camels were carried off and themselves put to the sword, are events often realised in the modern history of Palestine. A certain ill-regulated police prevails in the towns, under the rule of the Turkish pashas, though without any sure protection either for life or property; and their power is as frequently used in plundering as in protecting their subjects. But throughout the deserts there is no form of civil order or authority to control the lawless violence of the Arab hordes, and life and property are only held by the tenure of the sword. All ranks, accordingly, whether cultivators or traders, carry arms; partly, says Mr Buckingham, that their country is sometimes scoured by horse Arabs from the eastern deserts, when they must stand on their defence, "and partly because it is the fashion to be armed, insomuch that the being without weapons of some kind or other is always imputed to great poverty or to cowardice." Manners are formed by circumstances, and this habit of wearing arms strongly marks a disorderly state of society. The unhappy peasantry may be regularly plundered by the pashas, or by a sudden inroad of Arab horsemen. The fields are in this manner neglected; the country in many parts lies desolate; the fertile soil, to use the expression of an eloquent writer, maintaining an unequal conflict between the bounty of Providence to renovate, and the wickedness of man to destroy. In the more barbarous parts, where the cultivators live in a state of complete independence of pashas or other governors, there is no private property in land. It is so abundant that the only claim to any particular spot is having ploughed it, which entitles the person to the produce of the harvest for that season. The dress of those Arabs in Palestine, and throughout all Syria, especially of the men, is simple and uniform, consisting of a blue shirt of cotton cloth descending below the knees, the legs and feet being exposed, or covered with ancient buskin, or with the sandal exactly as it is seen on some Grecian statues. They sometimes wear a cloak of very coarse and heavy camel's hair-cloth, with broad black stripes passing vertically down the back. It is one square piece, either with or without a seam down the back, as was the garment of our Saviour, for which the soldiers cast lots,—"it was without seam woven from the top;" and on this account it is always esteemed the more valuable. A small turban, or rather a dirty rag, is bound across their temples, one corner of which, sometimes fringed with strings in knots, is allowed to hang down. The Arab women seem as if they took pains to disfigure themselves. According to Dr Clarke, they render their persons

[1] Travels in Palestine, vol. ii. chap. xiii. p. 405.

[2] Ibid. vol. ii. chap. xiv. p. 460.

Palestine. as hideous and disgusting as any barbarians of the South Seas. Their faces, heads, and arms are tattooed and covered with hideous scars; their eye-lashes and eyes are always painted with some dingy black or blue powder; their lips of a deep and dusky blue; their teeth jet black; their nails and fingers brick red; and their wrists as well as their ankles laden with large metal cinctures studded with sharp knobs and bits of glass. Their countenances are further disfigured with other unsightly ornaments. A small button studded with pearl, or a piece of glass or any other glittering substance, is fastened by a plug and thrust through the cartilage of the nose. Sometimes they have a large ring depending from the nose, and covering the upper lip; in short, all the devices of vanity in this country have the effect of maiming and disfiguring rather than of adorning the persons of the Arabian females. The same state of society and manners prevails among the Bedouin Arabs who inhabit Palestine as among those who traverse the Arabian deserts; and for farther particulars of their peculiar habits the reader is therefore referred to the article ARABIA, where their character and customs are fully described.

When the promised land was divided among the ten tribes, Judah, Benjamin, Simeon, Dan, Ephraim, Zabulon, Naphtali, and part of Manasseh, were placed on the western, commonly called this side of Jordan, while Reuben, Gad, and the remaining part of Manasseh, were placed on the eastern side, commonly called beyond Jordan.

The following table contains the ancient Canaanitish division of Palestine, and its division among the twelve tribes compared with its division by the Romans.

Ancient Canaanitish Division.	Israelitish Division.	Roman Division.
Sidonians	Tribe of Asher (In Libanus.)	Upper Galilee.
Unknown	Naphtali (North-west of the Lake of Gennesareth.)	
Pheresites	Zebulon (West of that lake.)	Lower Galilee.
The same	Issachar (Valley of Esdraelon. Mount Tabor.)	
Hivites	Half tribe of Manasseh.. (Dora and Cæsarea), mingled with the following.	Samaria.
The same	Ephraim (Sichem, Samaria, district of Sarouas.)	
Jebusites	Benjamin (Between Ephraim and Judah. Jericho. Jerusalem.)	
Hethites, Amorites..	Judah (Hebron. Judea proper.)	Judea.
Philistines (Pentapolis, Palæstina propria.)	Simeon (South-west of Judah.)	
	Dan (Joppa, &c.)	
Moabites	Reuben (Peræa proper, southern Hesbon.)	Peræa.
Ammonites, Gilead...	Gad (Northern Peræa, part of Decapolis and of Ammonitis.)	
Kingdom of Bashan	Half tribe of Manasseh.. (Gaulonitis, Batanea.)	

The Canaanites and Israelites having long led the lives of shepherds, their limits are not quite distinct. Michaelis could not complete the researches which Reland and D'Anville began, nor can any one. The tribes of Simeon and Dan do not appear to have ever occupied their whole territory. The Philistines lived in them in a state of vassalage. The tribe of Asher was expelled from the sea-coast by the Tyrians: Reuben, Gad, and the eastern half of Manasseh, appear never to have subjugated all the Ammonites and Moabites. Palestine.

When the children of Israel took their departure from Egypt, Moses was their ruler and their guide. It was through him that their Divine Legislator gave them laws and statutes, the administration of which was also committed to him; and he led them through the wilderness, where they were fed by the miraculous interposition of heaven. But the burden of his office being too great for him, the judicial duties were divided; all lesser causes being, by the advice of his father-in-law, referred to the rulers of thousands, of hundreds, of fifties, and of tens,[1] while those of greater moment were only submitted to the chief judge; the power of making laws in this holy community being the high prerogative of its Divine head, and obedience being all that was required of man. The duties of a Jewish ruler were simplified and greatly abridged, being confined to the guidance of the host through the wilderness or in battle, though even here every important movement was directed by means of the pillar of the cloud by day or of the fire by night. History.

Moses was succeeded in his office by Joshua and the other judges; and when the host of the Israelites had obtained possession of the land of Canaan, which was to be equally divided as an inheritance among the ten tribes, and where they were to rest from all their toils, new laws were given them by the same authority, adapted to the situation in which they were now placed. The land was partitioned by lot among the different tribes, and was again subdivided among the families of the same tribe, and was declared inalienable, and the perpetual inheritance of the families to whom it was originally assigned. Accordingly, every fiftieth year, which was proclaimed to be a year of jubilee, all debts and mortgages on land were declared to be cancelled, and every man was to return into his own land, which was not to be sold for ever, but on which all burdens that had been incurred were to cease. Other laws were passed for enforcing the purity of divine worship and of moral conduct, and of equity in the transactions between man and man; also for the punishment of idolatry and other iniquities, for it was the peculiar distinction of this community, that the law took cognisance not only of offences against society, but of every breach of the divine commands. The order of the priesthood was also instituted in the family of Levi; gifts and sacrifices were offered by them in expiation of sin; and various acts were enumerated by which the children of Israel became unclean, and which, though innocent in themselves, were yet employed to point out the great defilement of sin, and for which, therefore, certain modes of purification were appointed. The distinction was also laid down between clean and unclean animals, from the latter of which the holy people were commanded to abstain. An enumeration was made in the plains of Moab, of all the males of the children of Israel above twenty years of age, and the sum of them is given at 601,700; the Levites, who were not mentioned among the rest, amounted to 23,000, which makes the sum of 624,700 males above twenty years of age. Every male being liable to military service, Israel could thus bring into the field a powerful military force, by whose irresistible attack, aided by the favouring interposition of heaven, all the minor states of Canaan were overwhelmed. After the death of Moses the supreme rule in Israel was vested in judges, under whom was an inferior officer, namely, the prince of the tribe, or the head of thousands; and under him the princes of families, or commanders of hundreds; though the powers possessed

[1] Exod. chap. xviii.

Palestine. by the chief judge have never been exactly defined, nor in what relation he stood to the other subordinate rulers in Israel. The Israelites, after their settlement in the land of Canaan, were involved in wars with the surrounding states, and were often given into their hands on account of their disobedience. The land was in this manner frequently wasted, and the earthly happiness of the chosen people interrupted, by the inroads of their neighbours. From these enemies they were saved by deliverers raised up to them, under whose peaceful sway the land enjoyed long intervals of rest. But during the old age of Samuel, in consequence of the perversion of judgment through bribery by unfaithful judges, the people were dissatisfied, and entreated, against the solemn protest of this aged prophet, that they should have a king, like the nations around them; and Samuel was desired to hearken to their request. Saul was accordingly chosen king, from whom, on account of his disobedience, the kingdom was rent, and given to David; and he terminated his fatal course in a disastrous defeat on the mountains of Gilboa, in which he and his son Jonathan were slain. David now ascended the throne without dispute, and commenced a prosperous reign, in the course of which he subdued all his enemies; and although the peace of the country was disturbed by the domestic treason of Absalom, yet he left a flourishing kingdom to his successor Solomon, under whose reign Judea was enlarged on every side, and became one of the most flourishing empires of Asia, extending on the east as far as the Euphrates, and, possessing ports both on the Mediterranean and on the Red Sea, had begun to rival Tyre in arts as well as in commerce. David was a man of war, but Solomon was devoted to peace; and during his reign, accordingly, was constructed that magnificent temple at Jerusalem, which was the wonder of future ages. From the ports of the Mediterranean, also, the trade of Judea was extended to the most distant parts. "Every three years," it is said, "once came the ships of Tarshish, bringing gold and silver, ivory, apes, and peacocks."[1] These are the productions of India, which Solomon had received from these ships, in exchange, it is said, for the fine wheat of Syria, which was largely exported. These ships of Tarshish, it is supposed, descending the Persian Gulf, stretched across the Indian Ocean to the coast of Malabar, whence they again returned with the favourable monsoon; a hazardous voyage in that early age, which, with the time put off in trading at the intermediate ports, might well occupy three years.

After the death of Solomon, the kingdom of Judah was divided into two sovereignties. The tyrannical conduct of Rehoboam, in which he persisted, against the advice of his aged councillors, gave rise to the revolt of the ten tribes, who chose Jeroboam for their king; and thus began that division of the empire which paved the way for its downfall, under the successive attacks of its enemies. The kingdoms of Israel and Judah were hereafter ruled by different monarchs, who, no longer joining against their common enemies, waged war against each other; and who, in place of the union that might have been expected in the descendants from a common stock, regarded each other with all the aversion of aliens. In the mean time, the powerful empires of Assyria and Babylon in the east, and of Egypt in the south, were now contending with each other for the dominion of the world. Their vast armies had frequently threatened the comparatively petty state of Judea; and at length, in the reign of Hoshea, 719 years before the Christian era, Samaria, the capital of the kingdom of Israel, was taken by the king of Assyria, the land was conquered, and the whole nation carried into captivity.

We subjoin a list of the kings who reigned in Samaria, with the length of their several reigns, and the period when they reigned. Palestine.

	Years.	B. C.
1. Jeroboam	22	990
2. Nadad	2	968
3. Baasha	23	966
4. Ela	1	943
5. Zimri and Omri	11	942
6. Ahab	22	931
7. Ahaziah	2	909
8. Jehoram or Joram	12	907
9. Jehu	28	895
10. Jejoahaz	17	867
11. Jehoash or Joash	16	850
12. Jeroboam II.	41	834
1st Interregnum	22	793
13. Zechariah and Shallum	1	771
14. Menahem	10	770
15. Pekahahiah	2	760
16. Pekah	20	758
2d Interregnum	10	738
17. Hoshea	9	728
Samaria taken	271	719

The kingdom of Judah, weakened by the loss of the ten tribes, was in its turn assailed by the king of Babylon. During the reign of Jehoiakim, Nebuchadnezzar invaded Palestine with a formidable army, which the Jews had no means of resisting; and the ruin of the nation was for a time only averted by prudent submission. But the humbled king, impatient of dependence, seizing, as he thought, a favourable opportunity, made a new effort to throw off the yoke of the king of Babylon. The siege and capture of Jerusalem was the consequence of this rash attempt, when the king and all the princes of Judah were carried captives to Babylon. His son Jehoiachin was set up to reign in his stead, who was also brought to Babylon, with all the precious vessels belonging to the temple, and Zedekiah was declared king. He, like his predecessors, took up arms against the king of Babylon, who, incensed by these repeated rebellions, resolved on the destruction of Jerusalem, and the utter extermination of the Jewish nation. Jerusalem was accordingly besieged by a powerful army; the Jews made an obstinate defence, and the siege lasted for about fifteen or sixteen months, in the course of which famine and disease raged within the walls of the city, which was at last taken and sacked, and all the chief inhabitants carried captives to Babylon, the poor of the land being only left to be vine-dressers and husbandmen. The king was severely punished for his rebellion; his sons were put to death before his eyes; he himself was deprived of his eye-sight, and being loaded with fetters, was carried prisoner to Babylon.

The following is the line of kings who reigned in Jerusalem from the death of Solomon to the destruction of the first temple.

	Years.	B. C.
1. Rehoboam	17	990
2. Abijah	3	973
3. Asa	41	970
4. Jehoshaphat	25	929
5. Jehoram or Joram	8	904
6. Ahaziah	1	896
7. Queen Athaliah	6	895
8. Joash or Jehoash	40	889
9. Amaziah	29	849
Interregnum	11	820
10. Uzziah or Azariah.	52	809
11. Jotham	16	757
12. Ahaz	16	741
13. Hezekiah	29	725
14. Manasseh	55	696
15. Amor	2	641
16. Josiah	31	639
17. Jehoahaz	3 mths.	
18. Jehoiakim	11	608
19. Coniah or Jehoiachin	3 mths.	
20. Zedekiah	11	597
Jerusalem taken	404	586

Seventy years were appointed as the term of the Jewish captivity, in the course of which the empire of Babylon was overthrown by Cyrus the king of Persia, under whose auspicious and friendly reign the Jews, consisting now only of the tribes of Judah and Benjamin, were encouraged

[1] 2 Chron. chap. ix.

Palestine. to rebuild their city, and to return to their own land. Zerubbabel, Nehemiah, and Ezra, were the leaders that presided over the restoration of the Jewish kingdom. After many interruptions from the jealousy and power of their enemies, the second temple was at length reared. But it was so inferior in splendour to the temple reared by Solomon, that the aged men wept when they contrasted this modern structure with the glory of the first house. There was wanting, besides, the ark, the holy oracle, with the emblematical light of the Divine presence, the Urim and the Thummim, from which the divine response was given to the inquiries of the high priest. The Jews were now ruled by the Persian king and his lieutenants, in civil though not in sacred things, which were regulated by the law of Moses, as administered by their own high priests; and they enjoyed for a period nearly of two centuries the blessings of a settled government. After the conquest of Persia by Alexander, and the division of his kingdom among his successors, Asia was distracted by new wars among those rivals for the supreme dominion, and the Jews, often embarrassed by these contentions, owed their independence rather to the forbearance of their enemies than to their own strength. At length, however, Antiochus Epiphanes, having heard of insurrections among them, invaded their territory with a powerful army, and besieged and took Jerusalem while it was yet unprepared for defence. He wreaked his vengeance on the unhappy Jews, 40,000 of whom were put to death, and an equal number reduced to slavery. Other unheard-of cruelties were perpetrated by his licentious soldiery, and the holy sanctuary itself was grossly profaned. The temple was plundered of all its sacred utensils, the golden candlestick, the table of shew-bread, and the altar of incense, and an unclean animal, a sow, was offered by his orders on the altar of burnt offerings; part of the flesh was boiled, and the liquor sprinkled around, where only the purifying blood of the holy sacrifice had been seen before. The Jewish nation was at the same time cruelly persecuted; an edict was issued for the extermination of the whole race; and, in furtherance of this barbarous policy, Apollonius, the commander of the troops, when the people had assembled in Jerusalem on the holy Sabbath, made a furious attack with his troops on the peaceful multitude, whom he slaughtered without mercy, or carried into a hopeless captivity. The city was plundered, and set on fire in many places; the walls were broken down, and a strong fortress built on Mount Zion, which commanded the temple and the adjacent parts. Having made these preparations, he proceeded to farther persecutions against the religion of the Jews. They were watched in their visits to the holy sanctuary, and harassed by the troops; the rite of circumcision was prohibited; and a compliance with the heathen idolatries was enforced at the point of the sword. They were compelled to profane the Sabbath, and to eat swine's flesh. The holy temple was violated by the worship of Jupiter, whose statue was erected on the altar of burnt-offerings, and the licentious revels of the Bacchanalia were substituted for the pure festivals of the Jewish church. The barbarities that were inflicted as the penalty of disobedience to these impious commands exceed all belief, and are too shocking to be detailed. The rage of persecution spared neither age nor sex; and all over the country torture and death were inflicted on the unhappy persons who, remaining stedfast in their faith, refused to participate in these heathenish rites.

But the tyrant who was thus aiming at the extermination of the Jews was scattering over the land the seeds of independence, and insuring his own overthrow. The unheard-of cruelties committed by his command excited the deepest indignation, and at length roused the nation to resistance. The heroic family of the Maccabees, consisting of five brethren, the sons of Matthias, a priest of the race of Asmones, were the champions of the patriotic cause. They were all of incomparable valour; and Judas having headed the insurgents, a determined band, though small in number, defeated the oppressors of his country in many great battles, and restored its independence. But he had to contend against domestic treason as well as foreign war. Alcinus, who was in the interest of the Syrians, assuming the title of high priest, claimed the allegiance of the Jews, and Judas was compelled in self-defence to seek the alliance of the Romans, who willingly sought a pretence for interference in the affairs of their neighbours. In the mean time the Maccabee chief was slain in the field of battle, and was succeeded by his brother Jonathan, who, employing his power in aiding Alexander in his competition for the throne of Syria, was allowed by him in return to unite the spiritual authority of the high priest with the temporal sway; and under this dynasty of the Asmonean princes Palestine was governed for more than a hundred years. Jonathan was succeeded by his son Simon, who secured the tranquillity of the country by cultivating the friendship of Rome. He was cut off, the victim of domestic treason, and John Hyrcanus, his younger son, ascended the throne. His reign was prosperous and successful. He not only threw off the Syrian yoke, but extended his territories eastward and northward. He besieged and utterly destroyed Samaria; and thus gratified the vindictive spirit of the Jews against the Samaritans. The short reign of Aristobulus, his son, followed; afterwards that of Alexander Jannæus, whose oppressions excited a civil war in the country. The insurgents, calling in the aid of the Syrians, became unpopular; and Alexander, after many reverses, at last succeeded in collecting a powerful army, with which he entered his capital in triumph, and took severe vengeance on his enemies, ordering a thousand men to be executed on the cross, and their wives and children to be butchered before their eyes. He was succeeded by his son, Hyrcanus the second. His brother Aristobulus, after secretly opposing him for some time, at length threw off the mask, and openly aspired to the supreme power. The two competitors were preparing to appeal to arms, when the Romans under Pompey, having subdued the greater part of Syria, were now called into Palestine as peaceable arbiters in this dispute. Aristobulus being, however, impatient, had recourse to arms, and shut himself up in Jerusalem, which was invested by the Roman general Gabinius, the lieutenant of Pompey, and carried by assault with prodigious slaughter. The authority of Hyrcanus was re-established, and Aristobulus was carried prisoner to Rome, whence afterwards making his escape, he raised the standard of revolt in Judea. But he had no force that could oppose the Roman armies under Mark Antony, who speedily re-established the authority of Rome in every part of the country. The rule of Judea was now delegated to Antipater, the minister of Hyrcanus, who appointed his two sons, Phasael and Herod, to be governors, the one of Jerusalem, the other of Galilee. But a new competitor appeared for the supreme authority in Judea, namely, a son of Aristobulus, who, having taken refuge among the Parthians, invaded the country with a powerful army; he laid siege to Jerusalem, which he took and pillaged; he put to death the eldest son of Antipater, Phasael, and rendered Hyrcanus incapable of the priesthood, by the extraordinary contrivance of biting off his ears. The Romans, however, now ruled in Judea; they were the supreme arbiters of its fate, and they placed on the throne Herod, the younger son of Antipater. He was of a cruel and jealous disposition, and in his fury he put to death his beloved wife, the beautiful Mariamne, the grand-daughter of Hyrcanus, her mother, brother, grandfather, uncle, and two sons; nor was he popular among Palestine.

Palestine. the Jews, owing to his attachment to and his open participation in the idolatrous rites of the Romans. He reigned thirty-four years. "A man," says Sandys, "full of admirable virtues and execrable vices; his acts had deservedly given him the addition of great; fortunate abroad, unfortunate in his family, his life tragical, his death desperate."[1] He died from the effects of a loathsome disease. He employed himself in works of architecture, particularly in the repair of the temple, by which he hoped to obtain favour among the Jews. It was in his reign that the Messiah was born, and it was from his cruelty that he fled into Egypt. He bequeathed his dominions to his two sons; to Archelaus the government of Idumea, Samaria, and Judea; and to Antipas that of Peræa and Galilee. Archelaus was soon after deprived of his great office, on account of mal-administration, and banished into Gaul. Judea was now reduced to the condition of a Roman province, under its own ruler or governor, who resided at Jerusalem, but who was subordinate to the prefect of Syria, which dignity was conferred on Publius Sulpicius Quirinus, who is mentioned in Luke's gospel under the name of Cyrenius. The government of Judea was conferred on Pontius Pilate, under whose authority the Saviour was crucified. The Jews were far from being a contented or happy people under the Roman yoke. They were exposed to the severe exactions of their delegated rulers, and to outrages and plunder by the Roman soldiers stationed in the province to overawe the people. Rebellion, provoked by these oppressions, and quelled by the legionary troops, became the pretext for fresh cruelties; and misery, disorder, and violence, thus reigned throughout the once happy land. The only portion of the country that enjoyed comparative quiet was Galilee and the country beyond Jordan, which was ruled by Antipas and Philip. It was the latter, Philip Herod, who married Herodias, his brother's wife, and who was afterwards banished to Gaul by Caligula. His nephew Agrippa was advanced to the government of all Palestine, with the title of king. His policy was conciliatory towards the Jews; he respected their worship, repaired and adorned the temple; while he joined with them in their persecution of the new sect of Christians, having cast Peter and James into prison. His melancholy end, being eaten of worms, is related in the Acts of the Apostles. His son Agrippa succeeded him, before whom, as is mentioned in the Acts of the Apostles, Paul pleaded his cause. The successors of Pontius Pilate in the government of Judea were Felix, Petronius, Festus, Albinus, and Florus. The provincial government of Rome was a pure despotism, without even those imperfect safeguards from oppression which existed at home. The great men of Rome were enriched by the spoils of the conquered provinces; the distance from the capital exempted them from control; nor was there any legitimate channel through which the aggrieved could seek redress. The discontent of the Jews, their impatience of the Roman yoke, their proneness to insurrection under the vain predictions of their soothsayers, that a conquering Messiah was to arise, who would restore the independence and glory of their country, afforded too fair a pretence for the severities of their rulers; and accordingly, though there were some, such as Festus, who followed the maxims of equity, yet the Roman yoke was heavy and oppressive, and the administration of Felix, Florus, and others, was corrupt and tyrannical in the extreme; the people were borne down by heavy exactions, they were irritated and trampled upon by a licentious soldiery; and when they were driven to rebellion by these atrocities, they were overwhelmed by the disciplined legions of Rome, and slaughtered without mercy. The country abounded, accordingly, in scenes of rapine and anarchy; the national faith and the holiest rites were despised and trampled upon; and at length, under the administration of Florus, the people flew to arms, and entered on their last and desperate conflict with the Roman power. The insurrection broke out in Cæsarea, the inhabitants of which, galled by cruel insults, declared their determination to resist to the last extremity. The Jews in the capital shared in this heroic determination, and made preparations for defence. Cestus, the prefect of Syria, advanced to the gates, and demanded an entrance for the Roman troops. The Jews refused to comply with this summons, and expecting an assault, they beheld the Roman army, to their surprise, in full retreat. They were pursued by the incensed multitude, and being overtaken in a difficult pass of the mountains, they were attacked by the infuriated Jews, and, after a great slaughter, were forced ignominiously to take flight. Palestine.

The intelligence of these disasters excited the indignation of Nero, who was then in Greece, against the rebellious Jews; and Vespasian, of tried valour and experience, was immediately sent to assume the government of Syria, and to calm the troubles of this distracted province. He entered Judea about the year 67, along with his son the renowned Titus, to whom was committed the conduct of the war. Many sanguinary battles were now fought between the contending armies, in which the tumultuary levies of the rebellious Jews were broken and dispersed by the veteran legions of Rome; towns and fortresses were successively taken; and the Jews, no longer able to face the enemy in the field, were driven within the walls of their capital, to which Titus with his victorious army lost no time in laying close siege. The defence was obstinate; the besiegers were brave and numerous, and employed all the resources of the military art in the attack on the devoted city. In the course of this protracted siege partial successes were obtained by the Jews, who fought bravely, and harassed the besiegers by frequent and successful sallies. But the defences of the city, strong both by nature and art, gradually gave way before the perseverance and skill of the Roman troops; and as Titus proceeded partly by blockade, he shut in the whole city with a wall, and the horrors of famine were added to all the other miseries which the inhabitants suffered. The walls, where they were shattered by the battering rams, or undermined by other arts, were thrown down; the most valiant of the soldiers rushed through the breach, and were engaged in a close and bloody conflict with the besieged, for the possession of the temple. "Both sides," says Josephus, "drew their swords and fought it out hand to hand. Now, during this struggle, the positions of the men were undistinguished on both sides, and they fought at random, the men being intermixed one with another, and confused by reason of the narrowness of the place, while the noise that was made fell on the ear in an indistinct manner, because it was so very loud. Great slaughter was made on both sides." But still there was no room for flight or for pursuit, the troops in dense masses being mingled together in the deadly struggle. It would be endless to detail all the horrors of this protracted siege; famine raged within the walls; every inch of ground was fiercely disputed; and prodigious numbers of men fell on both sides. But the Romans made a steady progress. Their ensigns were advanced on the battlements of the temple, which was set on fire; the battering rams were then directed against the walls of the upper city, and a breach being effected, the place was carried by storm; the inhabitants were everywhere put to the sword or made captives, and sold for slaves. The number of Jews who perished in the siege is estimated at 1,100,000; a far greater population than the city ever contained. But

[1] Sandys' History of the Holy Land, p. 144.

Palestine. the annual feast of unleavened bread, which took place at this time, had crowded the city with a vast concourse of strangers from all quarters, who, by the sudden approach of the hostile army, were shut up within the walls. When the Roman soldiers had ceased from their work of slaughter and desolation, because, says Josephus, there were no more people to slay or plunder, the city was consumed with fire; and the wall, except that which enclosed the city on the western side, and three towers which were left as quarters for the Roman garrison, was laid even with the ground by those who "dug it to the foundation; that there was nothing left to make those that came thither believe that it had ever been inhabited."

The Romans having thus reduced the country, divided that portion of it that was on this side of Jordan into the three tetrarchies of Judea proper, Samaria, and Galilee, the first comprehending the tribes of Judah, Benjamin, Dan, and Simeon, the second the tribes of Ephraim, Issachar, and part of Manasseh, and the latter the tribes of Zabulon, Asher, and Naphtali. The region to the east of Jordan was divided into the smaller districts of Peræa, Decapolis, Gaulonitis, Galauditis, Batanea, and Auranitis.

After the Roman armies were withdrawn from Jerusalem, many of the Jewish tribes returned to dwell in the ruined city, though the Roman emperor, indignant at the late rebellion, had placed a garrison of 800 troops on Mount Zion, in order to prevent any attempt to rebuild the sacred capital, the capture and sack of which was a fatal blow to the prosperity of the Jews, and was the commencement of a long era of calamity, which ended in the utter dispersion of the nation. A portion of the country was yet, indeed, unscathed by the flames of war; the towns on the coast submitting to the conqueror escaped the horrors of a siege and the penalties of rebellion, while the provinces beyond Jordan enjoyed tranquillity under the rule of the conquerors. But the Jews were discontented and rebellious under the tyranny of Rome; they still fondly believed that an earthly Messiah was shortly to arise, to free them from bondage, and to give them the dominion of the whole earth. They accordingly listened to the tales of every impostor, and were easily seduced into rebellion by vain hopes of national glory, that were never realised. Hence their continual insurrections, which exposed them still farther to the vengeance of the conqueror, and accelerated the crisis of their fate, when they were to be driven from their own land, and dispersed over the face of the earth.

"From the reign of Nero," says the historian of the decline and fall of Rome, "to that of Antoninus Pius, the Jews discovered a fierce impatience of the dominion of Rome, which broke out into the most furious massacres and insurrections." He then gives a recital of their cruelties, and enters into an enumeration of shocking atrocities, which he accuses them of having committed, on the suspicious authority of the heathen writers, who hated the Jews, and, from Tacitus downwards, give a distorted view of their institutions and national character. The fact however is certain, that, throughout the cities of Egypt, Cyprus, and Cyrene, the Jews stirred up fierce insurrections, and flew to arms in order to avenge themselves on their insulting foes. In the course of this internal war great cruelties were committed. But in the end the Jews were everywhere borne down by the discipline of the Roman legions, and paid the penalty of their rebellion with their lives. Their towns were sacked and destroyed, and it is estimated that half a million of them perished in the field. In the island of Cyprus, where they were encountered by the military skill of the Emperor Hadrian, they were vanquished with prodigious slaughter, and expelled for ever from the island. By acts of mutual cruelty, the animosity of both parties was inflamed; the sword of persecution was let loose against the Jewish religion by their conquerors; the rite of circumcision, the reading of the law and the observance of the Jewish Sabbath, and all the other memorials of the national faith, were forbidden. In the city of Jerusalem, which was to a certain extent repaired, a colony of Greeks and Latins was established, in order to preclude the return of the Jews, and all further hopes of the restoration of their kingdom. But the policy of the Romans was of no avail against the deep-rooted prejudices of this infatuated people; and no sooner had a new impostor arisen, of the name of Barcochab, "the son of a star," than the deluded Israelites hailed him as the light that was to dawn in the latter days, and usher in the day of their long-expected rest. They accordingly crowded to his standard; and in a short time he had mustered a powerful army of 200,000 devoted followers. Owing to the absence of the Roman legions, engaged at that time in distant service, important advantages were gained, and Jerusalem was again occupied by the insurgent Jews, besides about fifty castles, and numbers of open towns. But this career of success was speedily terminated by the arrival of Severus, afterwards emperor, with a large and well-appointed body of legionary troops; the Jews were overwhelmed by numbers, discipline, and military skill; their cities were taken and destroyed; and Bither, where the leader of the rebellion, Barcochab, had made his last stand, was stormed with great slaughter, and himself slain. Of the Jews it is estimated that 580,000 died on the field, and the remnant who escaped mostly perished by famine and disease, or amid the flames of their ruined cities. Under these ruthless devastations the country was at last converted into a desert; the inhabitants were either slain or driven into exile; and the divine denunciations were now literally fulfilled against this misguided people, that they should be scattered among all the nations of the earth.

The victors having thus satiated their vengeance, began in due time to relax their stern and intolerant policy. Under the mild rule of Antoninus Pius, the Jews were restored to their ancient privileges, to the freedom of worship, and to all their other national rites. They were now mingled with the nations, and were found dwelling in all parts of the Roman empire; and their general condition under the Roman emperors, as described by Gibbon, was not unfavourable. "The numerous remains," says this eloquent historian, "of that people, though they were excluded from the precincts of Jerusalem, were permitted to form and to maintain considerable establishments both in Italy and in the provinces, to acquire the freedom of Rome, to enjoy municipal honours, and to obtain at the same time an exemption from the burdensome and expensive offices of society. The moderation or contempt of the Romans gave a legal sanction to the form of ecclesiastical police which was instituted by the vanquished sect. The patriarch, who had fixed his residence at Tiberias, was empowered to appoint his subordinate ministers and apostles, to exercise a domestic jurisdiction, and to receive from his dispersed brethren an annual contribution. New synagogues were frequently erected in the principal cities of the empire; and the sabbaths, the fasts, and the festivals, which were either commanded by the Mosaic law, or enjoined by the traditions of the rabbis, were celebrated in the most solemn and public manner. Such gentle treatment insensibly assuaged the stern temper of the Jews. Awakened from their dream of prophecy and conquest, they assumed the behaviour of peaceable and industrious subjects. Their irreconciled hatred of mankind, instead of flowing out in acts of blood and violence, evaporated in less dangerous gratifications. They embraced every opportunity of overreaching the idolaters in trade; and they pronounced secret and ambiguous im-

Palestine. precations against the haughty kingdom of Edom."[1] This statement, though it has received a colouring from the deep-rooted prejudices of the author against the Jewish religion, is nevertheless substantially true, and contains a just view of the condition of the Jews throughout the Roman empire. No great change appears to have taken place in the condition of Palestine, until Constantine ascended the imperial throne. He was, as is well known, the first Christian emperor; and under his powerful patronage, and that of his mother the Empress Helena, splendid structures were everywhere erected in the Holy Land, in honour of the Christian faith. The bishop of Jerusalem was ordered to erect a splendid temple on the tomb of the Saviour; and the Empress Helena repaired to Palestine, in all the ardour of new-born zeal, to explore the country for the relics of the sacred sepulchre, which was buried under an edifice, said to be the temple of Venus, raised by the Emperor Hadrian. Besides the temple which covered the holy sepulchre, she gave orders for the erection of other edifices, one at Bethlehem over the manger of the Messiah, and another over the Mount of Olives, to commemorate the ascension. The land was gradually overspread with these memorials of Christianity; and chapels, altars, and houses of prayer, marked every spot which was memorable for any of the sayings or doings of the Saviour. The Jews beheld with indignation the rise of these Christian monuments within the precincts of the holy city. They were as much opposed to the Christian worship as to the heathen idolatry, but their influence was now at an end. Scattered in distant parts, they could no longer act with consistency or vigour; yet, so attached were they to their own ancient rites, that, however faint the chance of success, they were ready in crowds to rally round the standard of their ancient faith, wherever it was displayed, and to follow any daring leader into the field. But the time was past. They were rejected by the divine decree, and were no longer to be assembled as a nation in their own land. Jerusalem was now filled with the emblems of a new faith, and crowds of pilgrims were attracted from the most distant countries, by the eager desire of contemplating the place of the Redeemer's passion, and of all the previous incidents of his holy life. These visits were encouraged from various motives. They evinced, no doubt, the zeal of the new converts; and being at once a proof of piety and a source of profit, they were encouraged by the clergy of Jerusalem. "The zeal," says the eloquent historian of the Roman empire, "perhaps the avarice, of the clergy at Jerusalem, cherished and multiplied these beneficial visits. They fixed by unquestionable tradition the scene of each memorable event. They exhibited the instruments which had been used in the passion of Christ; the nails and the lance that had pierced his hands, his feet, and his side; the crown of thorns that was planted on his head; the pillar at which he was scourged; and, above all, they showed the cross on which he suffered, and which was dug out of the earth in the reign of those princes who inserted the symbol of Christianity on the banners of the Roman legions."[2] To these deceptions was added a list of pretended miracles, by which the ignorant were duped and robbed of their money; and in the mean time, amid all this pretended sanctity, Jerusalem presented the grossest scenes of immorality and vice. The veneration evinced by strangers for the holy city never seems to have influenced the lives or practice of these votaries of indolence or pleasure, the relics in their possession being valued merely as a source of gain, and the means of worldly indulgence.

The reign of Julian was a new era in the history of Palestine, and the Jews anticipated, from his declared enmity to Christianity, his favour for their own purer faith. The Palestine. policy of this heathen emperor countenanced them in this belief, when he endeavoured, by rebuilding the temple of Jerusalem in its former splendour, to discredit the truth of those prophecies which denounced perpetual desolation on the devoted city. He chose the commanding eminence of Mount Moriah for the site of a new structure, which was to eclipse the splendour of the Christian church on the adjacent hill of Calvary; and he resolved to establish a Jewish order of priests, who might revive the observance of the Mosaic rites, together with as numerous a colony of Jews as could be collected, in the holy city. Such was still the ardour of the national faith, that the Jews crowded from all parts, and exasperated by their insolent triumph the hostility of the Christian inhabitants. All now joined with unwearied zeal in the sacred work of rebuilding the temple. Liberal contributions poured in from all quarters; men and women joined in the pious labour; and the authority of the monarch was seconded by the enthusiasm of the people. But this last effort of expiring zeal was unsuccessful; no temple ever arose on the ruins of the heathen edifices; a Mahommedan mosque still stands on the ground of the Jewish temple; and the progress of the work, according to a fable generally believed at the time, was stopt by the terrific interposition of heaven, by flames of fire bursting out from the foundations of the temple with loud explosions, by which the workmen were so terrified that they refused on any consideration to continue their labour. This miracle is indeed attested by contemporary historians; but it is justly remarked by Gibbon, that the original evidence of impartial and intelligent spectators would still be necessary to establish its truth. Now this evidence is wanting; for though it is recorded by the Roman historians, among others by Ammianus Marcellinus, yet he reports it merely on hearsay; and it seems probable that, at the distance of twenty years, without any anxious inquiry, he might take the story on credit, that he might "adorn his history with the specious and splendid miracle."[3] The work, however, from whatever cause, was abandoned; and as it was only undertaken during the last six months of Julian's reign, the fact seems sufficiently explained without the aid of a miracle, by the absence and death of the emperor, and by the new maxims that were adopted during the Christian reign that succeeded.

After the death of Julian it was the policy of the Christian emperors to depress the Jews in Palestine, though they were not ill treated throughout the provinces, and were even granted considerable privileges and immunities. But it is astonishing how carefully the fathers instilled into the minds of their children, along with their ancient faith, the fondly cherished delusion, that some new and happier era of freedom and independence was yet to dawn on Judea; and how eagerly the children, imbibing this idea, became the prey of every impostor, and, under the blind impulse of enthusiasm, rashly entered into new conflicts with their enemies in the field, where they perished the willing victims of a hopeless cause. About the beginning of the seventh century the peace of Judea was seriously disturbed by the Persian invasion of Chosroes. The Greeks and the Persians were for a long period rivals for the dominion of the East; and Chosroes, the grandson of Nushirvan, now invading the Roman empire, successively stormed and sacked the cities of Antioch and Cæsarea. From Syria the flood of invasion rolled southward on Palestine, and the Persian army was joined by the Jews to the number of 24,000, still burning with the love of independence. The Christians and Jews were inflamed against each other by a long course of deep injuries given and received.

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[1] Decline and Fall of the Roman Empire, vol. ii. chap. xvi. p. 386.
[2] Ibid. chap. xxiii. p. 101.
[3] Ibid. chap. xxiii. p. 109.

Palestine. Those of the former nation within the walls were massacred without mercy by their Christian enemies, while the Jews on the outside were burning with the desire of revenge. The advance of the Persians secured the triumph. The city was stormed by the combined armies, and the Jews were satiated with a full measure of revenge. The Christians neither sought nor found mercy; it was estimated that 90,000 of them perished in the storming of the city. Some were sold for slaves, and others were bought for the purpose of being murdered. The city was sacked, and the magnificent monuments of the Christian faith were mostly consumed by fire. The sepulchre of Christ, and the stately churches of Helena and Constantine, rifled, to use the words of Gibbon, in one sacrilegious day, of the devout offerings of three hundred years, were abandoned to the flames. But this, like all the other triumphs of the Jews, was short-lived. Heraclius was roused from inglorious sloth by the triumphs of the Persian arms, and by the approach of the victorious force to the walls of his own capital. He quickly assembled his veteran armies, by whose aid he defeated the troops of Chosroes; and in the course of a few successful campaigns he recovered all the provinces that had been overrun. He visited Jerusalem after his victories, in the lowly guise of a pilgrim, and prepared new triumphs for the Christians in the restoration of the magnificent churches which had been destroyed, and in the persecution of the Jews, and their banishment, as before, from the holy city, which they were now forbidden to approach within a nearer distance than three miles.

Palestine continued to own the sway of the Greek emperor till the rise of the Mahommedan power in the East. The followers of this impostor, extending their doctrines and their dominion by fire and sword, rapidly subdued Arabia, Syria, and Egypt, when, about the year 637, the victorious Omar turned his arms against Jerusalem, revered alike by Jews, Christians, and Mahommedans, as a holy city. After a siege of four months, during which the Arabs suffered extremely from the inclemency of the winter, a capitulation was proposed and agreed to, when the conqueror entered the city seated on a red camel, which carried a bag of corn and dates, and without guards, or any other precaution, and began to discourse in the most courteous manner with the patriarch, on its religious antiquities. Omar was assassinated in Jerusalem in the year 643, after which the East was for two hundred years distracted by the bloody wars that ensued among the Ommiades, the Abbassides, and the Fatimite caliphs; and Palestine having become an object of contest between them, was for a like period a scene of devastation and trouble. In the year 868, the capital was conquered by Achmet, a Turk; but was again recovered by the caliphs of Bagdad in the year 906. It was reduced by Mohammed Ikschid, of the Turkish race. Towards the end of the tenth century the holy city was taken possession of by Ortok; and in 1076 by Meleschah, a Turk. It was retaken by the Ortokides, and, finally, by the Fatimites, who held possession of it when the Crusaders made their first appearance in the Holy Land.

Jerusalem, though it was in possession of infidel chiefs, was still revered as a holy city both by Christian and Jew, and was visited by pilgrims from every quarter; among others by Peter the hermit, a native of Amiens. The pathetic tale which he brought to Europe, of the injuries and insults which the Christian pilgrims suffered from the infidels, who possessed and profaned the holy city, excited the deepest sympathy among the people and princes of Christendom. Councils were summoned, and were attended by bishops, a numerous train of ecclesiastics, and by thousands of the laity. At the council Palestine. of Trent no fewer than four hundred mitred prelates were present. The mixed multitude were harangued by the zealous enthusiasts of this sacred cause; their pity and indignation were alternately roused by the sufferings of their brethren in the Holy Land; the flame of enthusiasm was propagated by sympathy and example; and the eager champions of the cross, the flower of the European chivalry, assembled in martial array, to march against the enemies of their common faith. To defray the necessary expenses of the expedition, princes alienated their provinces, the nobles their lands and castles, peasants their cattle and the instruments of husbandry; and vast armies were transported to Palestine, in order to accomplish the deliverance of the holy sepulchre. These rude and undisciplined bands died in great numbers on reaching the shores of Asia, from disease, famine, and fatigue; and, of the first Crusaders, it is estimated that 300,000 had perished before a single city was rescued from the infidels. Of the leaders in the Christian host, the first rank is due to Godfrey, duke of Brabant and Bouillon, who was accompanied by his two brothers, Eustace the elder, who had succeeded to the county of Boulogne, and Baldwin the younger. The other chiefs were, Robert of France, the brother of King Philip, and Robert Duke of Normandy, the son of William the Conqueror; Bohemond the son of Robert Guisard, distinguished by his cool policy and ambition, with a small addition of religious zeal; Tancred his cousin, who had imbibed the true spirit of chivalry, and all the virtues of a perfect knight; and Raymond of Thoulouse, the Duke of Narbonne, and Marquis of Provence, a veteran warrior of mature age and experience. The vast armies that were collected under the guidance of these leaders arrived by various routes at Constantinople, the Greek capital; after having lost, some say, half their number, in the intermediate march through unknown countries, by famine, disease, and the assaults of the inhabitants into whose countries they had made so unexpected an irruption. After some time spent in the capital of the East, they crossed to the opposite shore of Asia. Having taken the towns of Nice and Antioch in the year 1097, they laid siege to Jerusalem about two years after, which was taken by assault, with a prodigious slaughter of the garrison and inhabitants, that was continued for three days, without respect either to age or sex. Women, and children at the breast, boys and girls, were dragged forth and put to death without mercy; and the streets were covered with their dead bodies and mangled limbs. Having thus delivered the holy sepulchre, the Crusaders proceeded, while yet stained with blood, to perform their devotions at the sacred shrine; they ascended the hill of Calvary bare-headed and bare-footed, amid the loud anthems of the clergy, and they kissed the stone of the Saviour's tomb, and bedewed with tears of joy and penitence the monuments of their redemption.[1] To such a degree does blind fanaticism harden the heart and stifle the voice of pity. The grand and leading trait of Christianity is benevolence to man, without which there can be no piety to God. This principle is inculcated both by the precept and example of its divine founder, who took care on all occasions to reprove and put down the spirit of persecution, however cloaked under the specious pretext of religious zeal. Yet we find here his professed followers, under show of deep reverence for his name, shedding without remorse the blood of their fellow-creatures, of women and children, and approaching, with their profane adorations, to the holy sanctuary of the God of peace.

Eight days after the capture of Jerusalem, the Latin

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1. Decline and Fall, vol. xi. chap. lviii. p. 85.

Palestine. chiefs proceeded to the election of a king, who should preside over their conquests in Palestine, and Godfrey of Bouillon was unanimously raised to this high office. But if it was an honourable office, it was also one of danger; he was not chosen to sway a peaceful sceptre; and he was summoned to the field in the first fortnight of his reign, to defend his capital against the sultan of Egypt, who approached with a powerful army. His signal overthrow in the battle of Ascalon confirmed the stability of the Latin throne, and enabled Godfrey to extend on every side his infant kingdom, which consisted only of Jerusalem and Jaffa, with about twenty villages and towns of the adjacent districts. The fortified castles, into which the Mahommedans had taken refuge, and from which they made incursions into the open country, were reduced; the maritime cities of Laodicea, Tripoli, Tyre, and Ascalon, were besieged and taken; and the Christian kingdom thus included a range of sea-coast from Scanderoon to the borders of Egypt. "If the province of Antioch," says the Roman historian, "disdained his supremacy, the courts of Edessa and Tripoli owned themselves the vassals of the king of Jerusalem; the Latins reigned beyond the Euphrates; and the four cities of Hems, Hamah, Damascus, and Aleppo, were the only relics of the Mahommedan conquests in Syria."[1] The feudal institutions of Europe were introduced into this kingdom in all their purity; and a code of laws, called the assize of Jerusalem, was drawn up, which was attested by the seals of the king, the patriarch, and the viscount of Jerusalem, and deposited in the sepulchre of the Saviour, as an unerring guide in all doubtful questions that might be brought before the tribunals of the holy city.

Godfrey was succeeded in his great office by his brother Baldwin, who ruled with vigour and success. In 1118 his nephew ascended the throne, and still maintained the interests of the kingdom. Melisandra his daughter married Foulques of Anjou, who, in right of his wife, acquired the kingdom of Jerusalem. He lost his life by a fall from his horse, after having reigned ten or twelve years. His son, Baldwin III., ruled in Jerusalem twenty years; and his reign was remarkable as the era of the second Crusade, and of the rise of the various orders of knighthood, the hospitallers, templars, and cavaliers.

The military force of the first Crusaders, wasted by fatigue, and by losses in the field, was no longer able to oppose the hosts of Turks and Saracens by which it was surrounded. The first victories of the Europeans, and their rapid success, extended far and wide the terror of their arms. But this alarm having subsided, the Mahommedan chiefs collected their armies, and commenced a vigorous attack on the European posts, scattered over a wide extent of country, and gained some important advantages. The accounts of these disasters that were circulated in Europe excited the liveliest sympathy of all Christians for their suffering brethren in the Holy Land, for the defence of which the European princes now entered into a new coalition. A second Crusade was the consequence. It was undertaken forty-eight years after the deliverance of the holy sepulchre, by the emperor of Germany Conrad III., and Louis VII. king of France, and was even more unfortunate than the first expedition. In the course of a tedious march through an unhealthy and hostile country, more than half the army of Conrad was wasted by famine and the sword, and not above a tenth part ever reached the Syrian shore. The subsequent battles with the Saracens reduced them to a miserable remnant; and the emperor was met by Louis and the French troops, who arrived in better condition at the scene of action, on his return with his shattered forces from this unfortunate campaign. The French army, rashly advancing into the heart of the country, was assaulted and overwhelmed by an innumerable host of Turks; and the king with great difficulty made his escape, and finally took shipping with his knights and nobles, leaving his plebeian infantry to the sword of the victorious enemy. The two princes proceeding to Jerusalem, united the poor remains of their once mighty armies to the Latin troops in Syria, and laid a fruitless siege to Damascus, which was the termination of the second Crusade. Palestine.

The defeat and dispersion of these armies tended greatly to weaken the Christian cause in the Holy Land, and shake the foundations of the Latin throne at Jerusalem. Baldwin, the son of Melisandra and of the Count of Anjou, together with his brother Amanry or Almeric, long maintained the war with considerable success against the infidels. Baldwin dying, was succeeded by his brother, who, after a reign of eleven years, transmitted the throne to his son Baldwin IV., disabled both in mind and body by the disease of leprosy. His sister Sybilla, the mother of Baldwin, was his natural heiress, who chose for her second husband, and consequently for king of Jerusalem, Guy of Lusignan, base in character, but handsome in his person. This choice was universally blamed, and excited the hatred of Count Raymond, who had been excluded from the succession and regency, and who, entertaining an implacable hatred against the king, was seduced into a traitorous correspondence with the sultan. Many of the barons were also so dissatisfied, that they refused to take the oath of allegiance to the new king. It was in the midst of these internal dissensions that the kingdom of the Latins was assailed by a new enemy, namely, the Sultan Saladin, who to valour, policy, and military skill, joined all the refined humanity of a Christian knight. He had risen from a private station to the sovereignty of Egypt, and he had been for years extending his influence and his dominions. A fortress had been seized by a soldier of fortune, Reginald of Chatillon, from which he issued with his followers to pillage the caravans and to insult the Mahommedans, and he even threatened the holy cities of Medina and Mecca. Saladin complained of these injuries, and being refused any satisfaction, invaded the Holy Land with an army of 80,000 horse and foot. He advanced against Tiberias, to which he laid siege; and a decisive battle was hazarded by the king of Jerusalem, in defence of this important place. The two armies met in the plain of Tiberias, and in a sanguinary conflict, which lasted two days, the Christians were completely overthrown, with the loss of 30,000 men, and a sacred relic, the wood of the true cross, with which the priests were wont to cheer the drooping spirits of the troops. The king, the Marquis of Montserrat, and the master of the templars, with many of their followers, were made prisoners; and two hundred and thirty gallant knights of the cross were cruelly led out to execution after the battle. This great victory placed the whole country at the mercy of the conqueror. The Christians were left without a head; of the two grand masters of the military orders, one was a prisoner, and the other slain. The fate of the kingdom had been set on a single cast, and its whole military force concentrated on this fatal field. The towns and castles, thus drained of their governors, fell successively before Saladin's victorious force; and scarcely had three months elapsed when he appeared in arms before the gates of Jerusalem.

This city was in no condition to sustain a protracted siege. It was crowded with fugitives from every quarter, who here sought an asylum from the destroying sword; a

[1] Decline and Fall of the Roman Empire, vol. xi. chap. lviii. p. 90.

Palestine. disorderly throng of 100,000 persons was confined within the walls, but there were few soldiers; the queen was alarmed for the fate of her captive husband, and her government was feeble and indecisive. A defence was, however, maintained for fourteen days, during which the besiegers had effected a breach in the wall, and only waited the sultan's orders for the assault. This last extremity was averted by a capitulation, by which it was agreed that all the Franks and Latins should quit Jerusalem, receiving a safe conduct to the ports of Syria and Egypt; that the inhabitants should be ransomed for a sum of money, and that those who were unable to pay it should remain slaves. These conditions were liberally interpreted and greatly mitigated by the generosity of the sultan, who allowed the poor to be ransomed by wholesale for a moderate sum, and freely dismissed about 3000 more. In his interview with the queen, he displayed the kindness and courtesy of his disposition, comforting her with his words, and even with his tears; he distributed liberal alms among the widows and orphans of those who were slain, and allowed the warlike knights of the hospital to continue their care of the sick for another year. He made his triumphant entry into the city, with banners waving and martial music; the Christian church was converted into a mosque, and the glittering cross was taken down and dragged through the streets, amid the shouts of the Moslems. The whole country now submitted to the sultan, whose victorious progress was first arrested by the resistance of Tyre, which was gallantly defended by Conrad. The sultan, being foiled in all his attempts to take this place, was finally compelled to raise the siege, and to retreat to Damascus.

The capture of Jerusalem by the infidels, and the decline of the Christian cause in Palestine, excited the deepest sorrow; the decaying zeal of the European powers was awakened, and new expeditions were fitted out for the recovery of the holy city. About the year 1190, Philip king of France, the Emperor Frederick Barbarossa of Germany, and Richard I. of England, surnamed Cœur-de-Lion, assembled a large force, and, with the aid of Flanders, Frise, and Denmark, filled about 200 vessels with their troops. The first armaments landed at Tyre, the only remaining inlet of the Christians into the Holy Land, and no time was lost in commencing the celebrated siege of Acre, which was maintained with an enthusiasm that mocked at danger, and by feats of valour that were the theme of wonder, even in that romantic age. This memorable siege lasted for nearly two years, and was attended with a prodigious loss of men on both sides. Famine, misery, and the climate, wasted the besieging army, and still the besieged held out with enduring firmness. At length, in the spring of the second year, the royal fleets of France and England cast anchor in the bay, with powerful reinforcements, and the brave defenders of Acre were reduced to capitulate. A ransom was demanded for their lives and liberties, of 200,000 pieces of gold, the deliverance of 100 nobles, and 1500 inferior captives, and the restoration of the holy cross. Thus was an important town and harbour obtained by the Christians, but by an enormous sacrifice of men. The host that surrounded Acre amounted at different periods to 600,000; of these, 100,000 were slain during the siege of two years, a greater number perished by shipwreck and disease, and it is computed that a very small remnant ever reached their native shores. The place was taken possession of by the Christians on the 12th of July 1191.

The capture of Acre was the prelude to farther operations against the enemy. Richard determined to commence the siege of Ascalon, about a hundred miles distant, and his march to this place was a continual battle of eleven days. He was opposed by Saladin with an army of 300,000 combatants; and on this occasion was fought one of the most memorable battles of this or any other age. Palestine. Saladin was defeated with the loss of 40,000 men, and the victorious Richard obtained possession of Ascalon and the other towns of Judea. A severe winter interrupted the operations of the field. But Richard, issuing from his winter quarters with the first gleam of spring, advanced with his army within sight of Jerusalem, the great object of his enterprise. Saladin had chosen Jerusalem for his headquarters, when the sudden appearance of the Christian conqueror spread universal consternation. The holy city was however relieved by the hasty retreat of the English king, discouraged by the difficulties of the enterprise and the murmurs of his troops. In the mean time the town of Jaffa was vigorously assaulted by Saladin with a formidable force, and was on the point of surrendering, when Richard, flying to its relief, encountered the besieging army of Saracens and Turks, amounting to 60,000 men, who yielded to the vigour of his attack. In the mean time the miseries of a protracted war began to be severely felt, and the ambitious views of Richard were obstructed by the discontent of his troops. Negotiations were commenced, which were broken off, and as often resumed. The views of both parties varied with the fortune of war. At last, however, both Saladin and Richard were equally desirous of terminating an unpopular and ruinous contest. The first demands of Richard were the restitution of Jerusalem, Palestine, and the true cross. These terms were rejected by the sultan, who would not part with the sovereignty of Palestine, or listen to any proposition for dismembering his dominions. A truce was at length concluded for three years, by which it was stipulated that the Latin Christians should have liberty to visit the holy city without being liable to tribute; that the fort of Ascalon should be dismantled; and that Jaffa and Tyre, with the intervening territory, should be surrendered to the Europeans. Soon after the conclusion of this treaty Richard embarked for Europe; and Saladin, his great rival, did not survive many months the conclusion of peace. He died at Damascus in the year 1193; and before he expired he gave orders that his winding-sheet should be carried as a standard through every street of the city, while a crier went before and proclaimed with a loud voice, "this is all that remains of the mighty Saladin, the conqueror of the East."

The fourth Crusade was encouraged by the zeal of Pope Celestine III. It was directed against the Greek empire, which was too feeble to resist so formidable an attack; and the result was its conquest by the Latins, who ruled over it for fifty-seven years.

In the mean time, in Palestine, though partial successes were gained by the armies of the Crusaders, their power was on the decline. A truce had been concluded with Saphadim, the brother and successor of the Sultan Saladin, for six years. The sovereign of the Latin kingdom at this time was Mary, the daughter of Isabella by Conrad of Tyre, Almeric and his wife being dead. In order to strengthen the government of Jerusalem, it was resolved to request the king of France, Philip Augustus, to provide a husband for Mary. John de Brienne, one of the most accomplished cavaliers in Europe, of tried valour and experience in war, was chosen; and the Christian chiefs were so elated by this union, that they sought a pretence for breaking the subsisting truce between them and the sultan, and bringing matters to the arbitration of the sword. War accordingly ensued, and the new monarch of Jerusalem displayed all the great qualities of a statesman and a soldier, for which he was chosen; and though his success did not entirely correspond to his hopes or wishes, yet he made a successful defence, and maintained for a time the Latin kingdom against the growing power of its enemies. He foresaw, however, that its gradual decline and final ruin was approaching, being now reduced to two or three

Palestine. towns, and preserved only in a precarious existence by the divisions and civil wars that prevailed among its enemies.

This intelligence rekindled the dying zeal of the Christian world. A new Crusade was commenced, and in 1216 a large force, chiefly of Hungarians and Germans, landed at Acre. The sons of Saphadim, who now ruled in Syria, collected their armies to oppose this formidable attack. But the Crusaders, rashly conducted, and weakened by divisions, advanced into the country without concert or prudence; provisions failed them; they were wasted, as usual, by famine and disease; and at length their leader, the sovereign of Hungary, resolved to quit a country where he had been exposed to hardship and danger, without glory. The crusading armies, thus weakened and discouraged, had laid aside all further idea of offensive operations, when, in the spring of the following year, a fleet of 300 vessels, that sailed from the Rhine, appeared on the coast, and brought to their aid powerful reinforcements, that recruited their strength, and restored their ascendency in the field. For reasons that do not clearly appear, they now retired from Palestine, and carried the war into Egypt, where they obtained important successes, having taken Damietta by storm, and spread such consternation among the infidels, that the most favourable terms of peace were offered, and rejected by the Crusaders, who, having wasted their strength on the banks of the Nile, were reduced to the necessity of bargaining for permission to retire to Palestine, by the cession of all their conquests in Egypt.

The next Crusade was undertaken by Frederick II., the grandson of Barbarossa, according to a vow which had been long made, and the performance of which had been so long delayed that he was excommunicated by Gregory IX. By his marriage with Violante, the daughter of John de Brienne, he was the more especially bound to vindicate his right to the kingdom of Jerusalem, which he had received as a dowry with his wife. After many delays, he set sail with a fleet of 200 sail and an army of 40,000 men, and in the year 1228 he arrived at Acre. This was the most successful and the most bloodless expedition that had yet been undertaken. Without the hazard of a battle he entered Jerusalem in triumph. The Saracen power was at this time weakened by divisions; and, owing to suspected treachery among his kindred, the son of Saphadim held rather a precarious possession of the throne. It was his policy, therefore, rather to disarm the hostility of these powerful armies by treating with them, than to encounter them in the field; and accordingly a treaty was concluded, by which Jerusalem, Jaffa, Bethlehem, Nazareth, and their dependencies, were restored to the Christians; religious toleration was established, and the contending parties of Christians and Mahommedans were allowed each to offer up their devotions, the first in the temple of Solomon, and the last in the mosque of Omar. But all these services were performed by Frederic while under the stain of excommunication; and hence the patriarch, when he made his entry into Jerusalem, refused to crown him, or to be present at the ceremonial; and Frederic himself took the crown from the holy sepulchre, and placed it on his own head. The stipulations of this treaty were not faithfully observed by the Saracens, and the Christians in Palestine still suffered under the oppression of the infidels. New levies were raised in Europe for the holy war, and a large force of French and English, led by the chief nobility of both nations, landed in Syria in 1239. Numerous battles were fought, which terminated in favour of the Saracens; and the French Crusaders, accordingly, after severe losses, were glad to purchase peace by the cession of almost all their conquests in Palestine. Next year, when the English levy under the Earl of Cornwall arrived at the scene of action, he found, to his surprise, that all the territories and privileges that had been ceded to the emperor of Germany were lost; and that a few fortresses, and a small strip of territory on the coast, comprised all that the Latins possessed in Palestine. He immediately prepared for the vigorous prosecution of hostilities. But the sultan, being involved in war with his brother in Damascus, readily granted favourable terms as the price of peace, namely, the cession to the Christian armies of Jerusalem, Beritus, Nazareth, Bethlehem, Mount Tabor, and a large tract of the adjoining country. But the kingdom of Jerusalem, thus so happily established, was subverted by a calamity from a new and unexpected quarter. In the interior of Asia the conquests of Ghenghis Khan had brought about the most stupendous revolutions, and the barbarous hordes of the desert, flying before his conquering sword, rushed like a torrent on other nations. The Kharismians, unable to withstand this powerful invader, were driven upon Syria, and the coalesced powers of Saracen and Christian were unable to resist their powerful assault. The Christian host was overthrown in a great battle, which lasted two days, and in which the grand masters of two orders, and most of the knights, were slain. The merciless invaders revelled in the sack and pillage of the holy city, sparing neither sex nor age; and it was not until the year 1247 that they were routed near Damascus, by the Syrians and Mamlouks, and driven back to their former settlements on the Caspian Sea. Palestine.

Each new disaster of the Christian arms served to rekindle the languishing zeal of the Europeans; and Louis IX. of France fitted out an immense armament for the Holy Land, consisting of 1800 sail of vessels, in which he embarked an army of 50,000 men. He landed in Egypt, and after storming the town of Damietta, he advanced along the sea-coast towards Cairo, when his troops were so wasted by sickness and famine that they fell an easy prey to the enemy. The king, with most of his nobles, and the remnant of his army, were made prisoners; and it was owing to the clemency of the sultan, who accepted a ransom for their lives, that Louis, with his few followers who remained alive, was permitted to embark for Palestine.

The power of the Christians in Palestine, weakened, among other causes, by internal dissensions, was now vigorously assailed by the Sultan Bibars, the Mamlouk sovereign of Egypt. He invaded Palestine with a formidable army, advanced to the gates of Acre, and reducing the towns of Sephami and Azotus, massacred or carried into captivity numbers of Christians. The important city of Antioch yielded to his powerful assault, when 40,000 of the inhabitants were put to the sword, and 100,000 carried into captivity. The report of these cruelties in Europe gave rise to the ninth and last Crusade against the infidels, which was undertaken by Louis, the French king, sixteen years after his return from captivity. But, in place of directing his arms immediately against Palestine, he landed in Africa, and laid siege to Carthage, which he reduced. But he perished miserably on the burning sands of Africa, of a pestilential disease, which proved fatal also to many of his troops; and thus ingloriously terminated this expedition, which was the last undertaken by the Europeans for the recovery of the Holy Land.

The Europeans in Palestine, a feeble remnant, were now confined within the walls of their last stronghold, which was besieged by a Mamlouk host of 200,000 troops, that issued from Egypt, and encamped on the adjacent plain. In this their last conflict with the infidels of the Holy Land, the Europeans fully maintained the glory of their high name. They displayed all the devotion of martyrs in a holy cause, and performed prodigies of valour. But, equalled as they were in discipline, and fearfully overmatched in numbers, by their enemies, they were overborne by the weight and

Palestine. violence of their attacks, and in the storm and sack of the city all either perished or were carried into captivity. Thus terminated for ever all those visions of glory and conquest by which so many adventurers were seduced from Europe to the Holy Land, there to perish under the complicated perils of disease and the sword. The historian of Rome describes, with his usual force and eloquence, the last struggle of the Europeans in defence of Acre. "Whatever," he observes, "might be the vices of the Franks, their courage was rekindled by enthusiasm and despair; but they were torn by the discord of seventeen chiefs, and overwhelmed on all sides by the power of the sultan. After a siege of thirty-three days, the double wall was forced by the Moslems; the principal towers yielded to their engines; the Mamlouks made a general assault; the city was stormed; and death or slavery was the lot of 30,000 Christians. The convent, or rather fortress, of the templars resisted three days longer; but the grand master was pierced with an arrow, and, of 500 knights, only ten were left alive, less happy than the victims of the sword, since they had to suffer on the scaffold in the unjust and cruel proscription of the whole order. The king of Jerusalem, the patriarch, and the great master of the hospital, effected their retreat to the shore; but the sea was rough, the vessels were insufficient, and great numbers of the fugitives were drowned before they could reach the isle of Cyprus. By the command of the sultan, the churches and fortifications of the Latin cities were demolished; a motive of avarice or fear still opened the holy sepulchre to some devout and defenceless pilgrims; and a mournful and solitary silence prevailed along the coast, which had so long resounded with the world's debate." The other smaller towns which still remained in possession of the Christians yielded without a struggle to the Moslem arms, and, under the religious tyranny of the infidels which succeeded, the Christians in Palestine were everywhere reduced to the lowest degree of debasement. The pilgrims who still visited Jerusalem were exposed to insult and danger; and large contributions were exacted by their oppressors for a free passage through the Holy Land. The Mamlouk sultans of Egypt continued to rule over Palestine till the year 1382, when the country was overrun by a barbarous tribe from the interior of Asia. On their expulsion the sovereignty of the Egyptian sultans was again acknowledged, until the country yielded to the formidable irruption of the great Tamerlane. At his death Jerusalem reverted to the kingdom of Egypt, and was finally subdued by Selim IX. the sultan of the Turks, under whose barbarous regime it has continued for more than 300 years. The country was partitioned into provinces, in each of which a pasha ruled with a despotic authority equal to that of the sultan.

In this condition Palestine remained without any remarkable event in its history, except that for nearly three centuries it was the scene of domestic broils, insurrections, and massacres, until the memorable invasion of Egypt by the French army in 1799. Bonaparte, being apprized that preparations were making in the pachalik of Acre for attacking him in Egypt, resolved, according to his usual tactics, to anticipate the movements of his enemies. He accordingly marched across the desert which divides Egypt from Palestine, and invaded the country at the head of 10,000 troops. El Arish surrendered, and the lives of the garrison were spared on condition that they should not serve against him during the war. Gaza also yielded without opposition; and Jaffa, stormed after a brave resistance, was given up to pillage. And here, in opposition to every feeling of humanity, and to all the maxims of civilized war, was exhibited a scene of atrocity, in the massacre, in cold blood, of 4000 prisoners, which vies in cruelty with the darkest deeds of savage life, and has left an indelible stain on the character of the chief agent, and all his accomplices, in this bloody transaction. Palestine. The plea, that these prisoners were dismissed at Jaffa on the understood condition of not again serving during the war, and that, having violated this condition, they were liable to death, was not supported by any evidence. It was not proved that those who surrendered at Jaffa were the same persons who were dismissed at El Arish; and the story seems indeed to have been fabricated, as the best apology that could be offered for such unheard-of cruelty, after the murder was committed. In the circumstances in which he was placed, those prisoners were a most inconvenient encumbrance to the French general; of which, accordingly, he appears to have freed himself by the short process of a general massacre.

The French army proceeded without delay to form the siege of Acre; and this fortress, the last scene of conflict between the Christians and infidels of former days, became a modern field of battle, in which were exhibited prodigies of valour that rivalled the most renowned deeds of those chivalric times. Bonaparte, though a French convoy with battering cannon and stores for the siege had been captured by a British squadron under Sir Sidney Smith, still persevered in his resolution to reduce the place. The trenches were opened on the 10th of March; in ten days a breach was effected, and a desperate assault took place. For a time the garrison were overpowered, and gave way; but Djezzar Pasha, who had shut himself within the walls, and who was aided by Sir Sidney Smith with a body of British sailors, rushed forward among the thickest of the combatants, and, animating the troops by his example, drove back the enemy with heavy loss. Bonaparte still persevered in a series of furious assaults against the fortress, which were all most gallantly repelled; and after a protracted siege of sixty days, a last assault was ordered, which was equally unsuccessful with all former attempts, and was attended with the loss of some of his bravest warriors. This last failure dictated the necessity of an immediate retreat, which was accomplished with difficulty, in a tedious march through the burning desert, where hardship and privation of every sort was the lot of the wayworn soldier, and the sick and wounded were left in most cases to inevitable death. The French army was attacked during the siege by a powerful body of Turkish troops; and a detachment under Junot, in an engagement which took place near Nazareth, would have been cut to pieces by the Mamlouk cavalry, but for the timely aid of Napoleon. Kleber also, surrounded by an overwhelming body of the same formidable cavalry near Mount Tabor, and who by his presence of mind and military skill had kept the enemy at bay during a whole day, was saved by the artillery of Napoleon, which speedily scattered this cloud of horsemen over the face of the desert.

Of late years a new power has arisen in the East, namely, that of the viceroy of Egypt, who having collected large treasures and a well-disciplined army, openly renounced his allegiance to the grand signior. A war took place, in which the hasty levies of Turkey were broken and put to flight by the veteran troops of Egypt; and a series of brilliant successes fully established the independence of the viceroy. As the price of peace, large districts in Syria and Palestine were ceded to him. We have no certain accounts whether these countries have improved under his sway; but the levies which he imposed on them, of men and money, have, it appears, been severely felt, as the country has been the scene of insurrections which have been with difficulty quelled by his troops. His government is, however, an improvement on the tyranny of Turkey; and in time we may hope that the country will reap the fruits of his wiser policy. (F.)

Palestrina || Paley.

PALESTRINA, a town of Austrian Italy, in the province of Milan, and delegation of Venice. It is rather a village than a town, being situated on an island at the mouth of the river that stretches from Porto di Chioggia to Porto di Malomocco, a distance of nearly fourteen miles. It contains 5980 inhabitants.

PALEY, WILLIAM, D. D., was born at Peterborough in July 1743, where his father was then minor canon of the cathedral church. His father afterwards removed to Giggleswick, being appointed head master of the school at that place. Here his son was trained under his immediate inspection, and discovered a solidity of understanding, and a studiousness of disposition, which gave a fair earnest of his future eminence.

In November 1758, at the age of fifteen, he was admitted a sizar of Christ's College, Cambridge, and in October 1759 he became a resident member. When he left home his father could not refrain from expressing to his friends the anticipations he entertained of the figure which his son was destined to make: "He'll turn out a great man; very great. He has by far the clearest head I ever met with."

Shortly after his removal to Cambridge he obtained three scholarships. He was not at this time a close or laborious student; he spent much time in company, and improved himself rather by observation and reflection than by reading. When he appeared in the public school to make his first *act*, the spruceness of his dress, presenting a striking contrast to the habitual carelessness of his appearance, attracted very particular notice, and, aided by a singularity in his gestures and manner, occasioned much mirth amongst the spectators; but the uncommon success with which he acquitted himself had the effect of drawing crowds on all future occasions when he was expected to dispute. His eminent abilities created upon one occasion some degree of apprehension, when he proposed to argue against the eternity of future punishments. One of the heads of the college insisted on his relinquishing that question. Dr Watson, then moderator, and afterwards the celebrated Bishop of Llandaff, protected on this occasion Paley's independence. The latter, however, was averse to give offence; and at the suggestion of Dr Watson he retained the subject, but took the opposite side. He came off with much eclat, his talents having received the best scope for display from the high ability of his opponent, Mr Frere.

After obtaining with great honour his bachelor's degree in January 1763, he accepted of the situation of second assistant and Latin teacher in an academy at Greenwich, chiefly resorted to by young men intended for the army and navy.

In 1765 Mr Paley gained the first senior bachelor's prize by a Latin dissertation on "a Comparison between the Stoic and Epicurean Philosophy in their influence on Morals;" taking the side of the Epicureans, as a sect friendly to rational pleasures, and not, as their enemies supposed, indulgent to vicious excesses; whilst he condemned the affected austerity of the followers of Zeno, and showed from facts that it was compatible with the most flagitious crimes. It is a remarkable circumstance, as illustrative of the formality which often presides in university matters, that this dissertation narrowly escaped rejection, because the Latin text was accompanied by *English notes*, for the purpose of aiding philosophical accuracy where the Latin appeared liable to ambiguity.

Being ordained deacon at the proper age, he officiated as curate to Dr Hinchcliffe, vicar of Greenwich, where he continued to reside, though he gave up his situation in the academy.

Mr Paley was elected a fellow upon the foundation of Christ's College in June 1766; returned to reside in the university; took the degree of master of arts, and engaged in the business of private tuition. He took priest's orders in December 1767, and in 1768 he was appointed tutor of Christ's College, along with his friend Mr Law, already a distinguished scholar. The talents and assiduity of these two quickly raised the celebrity of their college to an unprecedented height. Paley's intimacy with Law was productive of much mutual improvement, and introduced the former to the acquaintance of his friend's father, the eminent Dr Edmund Law, who was soon after Bishop of Carlisle, but continued to reside in the university as master of Peterhouse. Mr Paley was at this time held in the highest esteem; and amongst his particular friends were numbered Dr Plumptre, professor of casuistry; Dr Waring, Lucanian professor of mathematics, who was in his department eminent beyond his contemporaries; and the accomplished Mr Jebb. He figured as a lecturer on mathematics, morals, and the Greek Testament, and afterwards on divinity. His method of lecturing was singularly happy, the result of a diligent study of the art of teaching. He soon discovered that, in moral disquisitions, more pains are required to make young minds perceive the difficulty than to make them understand the solution, and that some curiosity must be raised before an attempt is made to satisfy it. The discourses which he delivered at this time contained the germ of the principal works which he afterwards published on morals and theology. Paley.

The controversy on the propriety of requiring a subscription to articles of faith, as practised by the Church of England, was at this time much agitated at the two universities. At Oxford the High Church party was triumphant, and scarcely any individual ventured a whisper of opposition; but at Cambridge, talents and ingenuity were exercised upon both sides of the question. Paley favoured the claims of the reforming party; but, from motives of prudence, declined signing a petition for relief at that time drawn up, not entertaining such expectations of ultimate success as to be induced to take a public step so obnoxious to those on whom his future prospects depended. He told one of his friends in jest, that "he could not afford to keep a conscience;" a confession which will, no doubt, lay him open to the animadversions of those who reserve their censures for the subdued struggles of a mind of limited moral strength, whilst they excuse or applaud the oppressive system by which its efforts are overawed. Paley, however, soon after wielded his pen in a decided tone in the cause of freedom. Dr Law, the bishop of Carlisle, published an able and moderate pamphlet against the imposition of the church test. An answer appeared at Oxford from the pen of Dr Randolph. To this Paley published, anonymously, a reply, entitled A Defence of the Considerations on the Propriety of the Church Test.

His well-merited reputation induced that great constitutional lawyer, the Earl of Camden, to offer him the situation of tutor to his son; but his other engagements led him to decline the offer.

In 1775, he was inducted to the rectory of Musgrove in Westmoreland, worth about eighty pounds a year, presented to him by the Bishop of Carlisle. He now married Miss Hewit of Carlisle, and took a small farm to improve his income; a speculation which he soon after gave up as unproductive. Next year, he was inducted to the vicarage of Dalston in Cumberland.

In 1777, he was inducted to the vicarage of Appleby, worth about L.200 a year; and whilst in this situation he published a small volume, entitled The Clergyman's Companion in Visiting the Sick; in which he both evinced his personal attention to the spiritual wants of his own flock, and conferred an obligation on his brethren, which has been acknowledged by the numerous and large editions which it has undergone. In June 1780, he was installed a pre-

Paley. bendary of the fourth stall, in the Cathedral of Carlisle, worth about L.400 a year; and in August 1782, on the promotion of his friend Mr Law to the see of Clonfert, he was raised to the dignity of archdeacon of the diocese.

A report was long in circulation, that Mr Paley, being appointed to preach before the University of Cambridge when Mr Pitt made his first appearance at St Mary's after his elevation to the premiership, chose the following passage for his text: "There is a lad here who hath five barley loaves and two fishes; but what are they among so many?" That was not the fact; but the joke originated with Paley, who said to a friend that, had he been asked to preach on the occasion, he would have chosen this text.

Now in possession of a competent income, and sufficient leisure, he prepared for the press his great work On the Principles of Moral and Political Philosophy, which first appeared in 1785. In consequence of the well-known merit of his lectures on the subject of that work, high expectations were formed of it; and his admirers were not disappointed. Its most obvious feature was that of being all directed to the practice of life in cases which hourly claim the attention of well-meaning minds. Most other scientific works on morals were mere speculative treatises, which pleased the reader by unfolding the principles of right and wrong, in cases in which he has been previously satisfied about the practical rule and its application; whilst they embarrassed conscientious inquirers with hair-breadth distinctions, instead of conveying satisfactory principles. Dr Paley's work happily unites a due regard for practical duty with rational information on those points on which the mind is most anxious to obtain satisfaction. It soon established the reputation of its author. Some of his doctrines met with opposition, but he never was provoked to write any reply; and it is further remarked by his biographer, Mr Meadley, that, in the subsequent editions, he made no alterations materially affecting the sense. Had there been a few such alterations, however, he would have more fully merited the character of a liberal inquirer. Amongst his elucidations of the foundations of virtue, he certainly fails in his definition of "the nature of obligation." He acknowledges that the subject had embarrassed his own mind; yet he ultimately reposes in a solution founded on a confusion of terms, which laid him fully open to the animadversions of the Reverend Mr Pearson, who published An Examination of his Theory. Dr Paley's doctrine is, that "a man is under moral obligation when he is urged by a violent motive resulting from the command of another." He thus resolves obligation into an effectual inducement. According to this statement, a man is under no moral obligation unless he feels, acknowledges, and acts upon it. Had such a hypothesis occurred in the writings of an author who made the purity of practice to depend on the reception of peculiar theories, it might have created great laxity of principle in the minds of some persons, and distress in those of others. But his masterly elucidation of the rule of morals, and the paternal benignity with which his efforts are uniformly accompanied, set his reader at rest from all hurtful anxiety on practical topics.

His exposition of the rule of morals, as founded in utility, is ably managed. He demonstrates the superiority of this rule to every other, and the subordinate rank of all those mental suggestions and impressions which some moralists have represented as essential parts of the foundation of morality. Many such feelings are valuable provisions of the Author of our Nature, but they do not deserve the authority of guides. Their whole claim to our obedience is derived either from their coincidence with some express command of the Deity, or their conduciveness to utility. The difficulties attending inquiries into this conduciveness in particular instances do not generate uncertainties so great as those attached to the other supposed natural tests of moral truth. A man may be mistaken respecting the useful or hurtful *tendency* of a particular line of conduct; but he is equally liable to be led astray by feelings venerated as moral suggestions; and, under that influence, he is deprived of an equal possibility of correcting himself by subsequent reflection. When authors declaim on the danger attached to the doctrine of utility, they borrow their arguments from that doctrine itself. They merely set up utility in its extensive application against such utilities as are partial and delusive. Dr Paley, therefore, dwells strongly on the necessity and importance of *general rules;* and, by taking them for his guides, obviates all the serious objections brought against this leading theorem, "that the method of coming at the will of God concerning any action, by the light of nature, is to inquire into the tendency of that action to promote or diminish the general happiness." Paley.

On our duties to ourselves his observations are short, at which we cannot be surprised when we find that in his definition of virtue these duties are excluded. In the excellent casuistical Observations on Self-Defence, Drunkenness, and Suicide, of which this portion of his work entirely consists, he regards the tendency of personal conduct and habits only as they affect society around us. But if he had paid more respect to the maxims of the stoical authors, and studied them in their most favourable meaning, he would have been more disposed to point out the importance of maintaining mental composure as an ultimate object of individual efforts. On our duties towards God he also treats briefly. The simplicity attached to our knowledge of their great object divests them of variety as a separate subject, without detracting from their sublimity.

In the political part of this work, we find the exertions of a manly understanding employed with some success in exposing the dark bigotry and the gratuitous king-worship by which political knowledge had in past ages been disgraced. His efforts, however, are exempt from those headstrong tendencies which minds liberated from unfair control sometimes betray, and thus run into schemes incapable of being applied without compromising the happiness of society. That happiness he keeps steadily in view, as the only legitimate object of all government, as well as the only legitimate object of opposition to existing practices and institutions. Some of his admirers consider him as going too far in vindicating the exaction of a subscription to the Thirty-nine Articles. His chapter on subscription has been assailed with equal asperity by the strenuous adherents of the established church, and by the scrupulous advocates of Protestant freedom. His biographer, Mr Meadley, calls it "the last effort of an ingenious mind to soften, by interpretation, the rigour of a practice of which he could not seriously approve, and so to enlarge the pale of conformity to liberal and conscientious men."

The answer which he gives to the arguments for passive obedience as founded in Scripture, is particularly worthy of attention. Throughout the whole he displays a candour of the most conciliating kind. None of his strictures on existing systems had the slightest tendency to give offence to any, except to persons actuated by downright prejudice, or the most corrupt motives.

On the death of Dr Law, bishop of Carlisle, which happened in 1787, Mr Paley published a short Memoir of the life of that venerable prelate. Soon afterwards he wrote two tracts in favour of "the abolition of the slave-trade;" a subject on which he had expressed his sentiments with decision in his Principles of Moral and Political Philosophy, before it began to excite general interest.

In 1790 he published his *Horæ Paulinæ*, or the Truth of the Scripture History of St Paul evinced, by a comparison of the Epistles which bear his name, with the Acts of the Apostles, and with one another. The object was to show, by a copious selection of references and reciprocal

Paley.

allusions, the strong evidence of their genuineness derived from their undesigned coincidence. This able treatise possesses more novelty of interest, and greater originality of idea, than any of his other works.

During the violent political ferment which led to the French Revolution, Dr Paley published a short tract, entitled Reasons for Contentment, addressed to the Labouring Classes; and he republished, in a separate form, his chapter on the British Constitution, from his Principles of Moral and Political Philosophy. He was censured by the violent partisans on both sides, as he went the full length of neither; but his style of reasoning had the best tendency to guide and satisfy those minds which were not obstinately and unreasonably prepossessed.

In May 1791, Mrs Paley died, leaving him a family of four sons and four daughters.

Early in 1794 he published his View of the Evidences of Christianity. This work, with regard to manner and effect, follows a happy medium between that learned prolixity which deters the reader, or tires out his patience, and that abrupt brevity which is apt, with some minds, to beget an unfortunate impression of some imperfection in the argument. He contends for the substantial truth of the history connected with the Christian revelation; and, not undervaluing, as some have injudiciously done, the internal evidences, he exhibits, in primitive simplicity, and without the least oratorical exaggeration, the superlative value of those doctrines in which all Christians are agreed, and gives an animated view of the morality of the gospel. The work, considered as addressed to doubting minds, was well fitted to interest the attention of all who are duly impressed with the importance of the question at issue.

Hitherto his preferment in the church had been slender, considering his singular merit and the opulence of the ecclesiastical establishment. But the boldness of his reasonings on political subjects had given deep dissatisfaction. To the favourers of power it was not welcome doctrine, that "governments may be too secure;" that "the obligations of subjects and sovereigns are reciprocal;" and "that the divine right of kings rests on the same foundation with the divine right of constables." But when he stood forth as the successful defender of the Christian revelation, at a time when the interests of the church were supposed to be in danger, his services met with more marked attention. Dr Porteous, bishop of London, conferred on him the desirable situation of prebend of St Pancras in the Cathedral of St Paul's, to which he was instituted in August 1794. He was in a few months afterwards promoted to the subdeanery of Lincoln by Dr Prettyman, bishop of that diocese, and took his degree of D. D. at Cambridge.

Before leaving this place, he had the agreeable surprise of a letter from Dr Barrington, bishop of Durham, offering him the valuable rectory of Bishop-Wearmouth, worth about L.1200 a year, into which he was soon inducted. A few months afterwards he married Miss Dobinson of Carlisle; and, from this period to his death, divided his time between Bishop-Wearmouth and Lincoln, being obliged to reside three months in the year at the latter place. Now that he enjoyed a handsome independence, we find his company courted by many distinguished characters, and his life spent in a series of the most useful labours, whilst all his secular transactions were so well conducted, as to shed a lustre on his character, and to exhibit a most instructive example to all around him. Both his parents lived to witness his high reputation and success in life. His mother died in 1796, and his father in 1799.

In 1800, Dr Paley was attacked by a disease in the kidneys, accompanied with a species of melæna, which obliged him to suspend the discharge of his professional duties. He had a second attack in the following spring, and a third about the end of 1802. Palfrey.

During the progress of this fatal disease, he was engaged in preparing for the press his last important work, On Natural Theology. His literary labours were frequently interrupted by severe paroxysms of pain, but on the first respite he always resumed them with cheerfulness. Under these circumstances, he wrote his excellent remarks on the alleviations of pain, in his chapter on the Goodness of the Deity. This work had been undertaken at the suggestion of the Bishop of Durham, that he might, by theological exertions in his closet, make up for the unavoidable suspension of his public ecclesiastical labours. In none of his writings does his candour appear to such incontestible advantage as in this. We never find him browbeating the adversary, or attempting to push his conclusions a single step farther than his premises evidently warrant. We do not find him, like many others, advancing the metaphysical position "that every thing which exists must have a cause," so glaringly open to the query, "why should the world have a cause more than its Creator?" Mere existence cannot authorize the inference of owing that existence to a higher source. He rests his argument on far better ground; the *character* of the fabric of nature, or rather of various objects in it which offer themselves to our observation. Nor does he, with some, assume the doctrine, that matter is essentially inert, and that, therefore, its motions must be induced by an extraneous and spiritual cause. He more wisely turns his attention to the proofs of *design* which so many objects in the world exhibit. These are so selected and arranged as to appear in the most interesting and satisfactory point of view. Where the phenomena are apparently inconsistent, we find no straining to reconcile them; no reluctance to take a full view of unfavourable appearances; no inclination to draw the same inferences from opposite facts. His argument is not suspended on a chain of metaphysical reasoning, which would have subjected it to the risk of destruction as soon as one of the links gave way. He directs the attention of his reader to numerous columnar supports of the existence of a God, each of which is adequate to the whole office. Each instance produced is decisive of the point at issue; and though his instances are numerous as well as beautiful, they are evidently only partial exemplifications of a species of evidence which is boundless in extent.

In the present state of the learned world, this is perhaps the most important of Dr Paley's works; as possessing the best tendency to reclaim persons wandering in the mazes of scepticism, to that state of thought which is most favourable to the true improvement of the human character; and to the establishment of that state of mental peace after which a sense of our weakness naturally leads us to aspire.

After its publication, Dr Paley continued to take a lively interest in the literary and scientific discussions of the day, especially such as bore directly on the great interests of society; but in May 1805, he was subjected to a violent attack of his complaint, in which all remedies proved ineffectual; and, with great tranquillity, he breathed his last at Bishop-Wearmouth, leaving a family of four sons and four daughters in possession of a competent fortune, saved by a systematic though by no means a niggardly economy.

He wrote several sermons and other minor productions, less known than those above enumerated. They are all collected in a uniform edition of his works, and will be found, on examination, worthy of his fame, and successfully directed to the same valuable ends with his more celebrated productions. (P. P. P. P.)

PALFREY is one of the better sort of horses used by

Palgunge || Palimpsests.

noblemen or others for state, and sometimes of old taken for a horse fit for a woman to ride.

PALGUNGE, a town of Hindustan, in the province of Bahar, and district of Monghir, 122 miles south-east from Patna. Long. 86. 15. E. Lat. 24. 5. N.

PALHAUNPOOR, a town of Hindustan, in the province of Gujerat, and district of Dandur. Long. 72. 35. E. Lat. 24. 44. N.

PALICAUDCHERRY, a town of Hindustan, in the province of Malabar. In the year 1766, Hyder Ali gave orders for building here a strong stone fort, which might serve as a point of communication between his new conquests and his fixed resources in the district of Coimbetoor. It is situated in the middle of the teak forests, on the bank of the Paniany River, by which, during the rainy season, any quantity of wood may be floated down to the seaport of Paniany, and from thence conveyed to Bombay or Ceylon. Around the fort are scattered many villages, estates, and bazaars; but there is little appearance of a town. The surrounding district contains 123,074 inhabitants. It was ceded to the British by Tippoo in 1792. The fort is 110 miles south from Seringapatam. Long. 76. 50. E. Lat. 10. 50. N.

PALIMPSEST, in Greek παλιμψηστος (a word formed from παλιν, *again*, and ψαω, *to wipe, cleanse*, or *rub*), is a term applied to a manuscript, from its having been twice cleaned, or twice written, that is, *rescribed*.

The value of ancient manuscripts has long been rightly estimated, and hence in every part of Europe they have been collected at great expense, and preserved with the utmost care. For some time after the invention of printing, it was indeed thought that when the contents of a manuscript had been copied, and multiplied by means of that invaluable art, the original was rendered useless. But as different manuscripts of the same work often vary in particular readings, it was soon found necessary to examine and collate a number of them, in order to ascertain the preferable readings; and without this previous care, conjoined with critical discrimination, a new edition of an ancient work would not now be well received by the learned. Such, then, is the most direct and obvious use of ancient manuscripts; which, when duly collated, furnish the means of restoring texts that had been corrupted or mutilated in the course of frequent transcription.

But, on a more minute examination of a certain class of manuscripts, it appeared that some of them might have a value hitherto unsuspected, by supplying more ancient copies than were previously known, and even furnishing portions of important works which were supposed to be entirely lost. These were manuscripts in which an attempt had been made to obliterate some more ancient writing, that the parchment might be again used to receive another work. This practice was not uncommon in the darker ages, both before and after the thirteenth century, when the material was scarce and dear, and the older works were either not understood or not duly appreciated. But, happily, the endeavour to rub out or obliterate the original writing had sometimes so far failed, that an attentive eye could, with more or less difficulty, discover traces of the older letters, and even decipher words; and certain manuscripts of respectable antiquity were thus found to conceal others several centuries older, and frequently of much superior interest and value. Manuscripts of this kind, therefore, received from the learned the name of *Palimpsest* or *Rescribed*, and became objects of curious and interesting investigation.[1] Palimpsests.

This term was not unknown to the ancients; but they applied it chiefly to leaves or books which were so prepared that one writing could easily be expunged to make room for another, and which were used by authors for correcting their works, or submitting them to revision. In this sense, palimpsests are mentioned by Cicero, Plutarch, and Catullus; and the poet, in particular, ridicules a bad author for not writing his works at first on palimpsests, but entering them at once, crude and uncorrected, in fine and costly books. But the palimpsests now to be considered are of much superior importance. They have opened to us some great discoveries, and given promise of many more. Some invaluable fragments of ancient works, believed to be entirely lost, have already been recovered; and the hopes which may fairly be entertained of future acquisitions from the same source, will best be estimated by a short account of what has actually been effected in exploring it.

The first rescribed manuscript of which any important use was made appears to have been the *Codex Ephrem* or *Codex Regius* of Paris.[2] The more modern writing in this manuscript contains certain works of Ephrem the Syrian, in Greek; the more ancient seems to have contained the whole of the Old and New Testament, in a character and style of Greek writing which the best critics have assigned to the sixth or seventh century. Of this manuscript there are 209 leaves remaining, but so miserably confused and misplaced, and with so many chasms of various kinds, that sometimes scarcely a word can be deciphered in a whole leaf. But the difficulties occasioned by these defects and mutilations have not deterred critics from endeavouring to make the most of the *Codex Ephrem*. From it Kuster first obtained several readings; and Wetstein afterwards collated, with great diligence, all that it contains of the text of the New Testament. Griesbach considers this as the most ancient manuscript collated by Wetstein; and there can be no doubt that the readings thus obtained confer a particular value on his edition. How much of the Old Testament may remain in this *codex* has not yet been ascertained, nor has that part of it been collated, even for the Oxford Septuagint; a circumstance at which Griesbach expressed his surprise when he published the first part of his *Symbola Critica*.[3] This valuable palimpsest was originally pointed out for critical examination by the learned Montfaucon.[4]

The next discovery amongst manuscripts of this description was one of a very interesting kind. Ulphilas, bishop of Gothland in the fourth century, is known to have trans-

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[1] The strict and precise sense of *Palimpsest* is "twice prepared for writing;" the repetition of such preparation being the prevailing idea in the etymology, and not erasure or obliteration, as Du Cange and others have supposed. It is indeed easy to remove from parchment, by rubbing it with pumice-stone, or some similar substance, all traces of the original writing, especially if it be of some antiquity; and if the surface be afterwards smoothed and polished, no one, by merely looking at it, would suppose that it had ever been written on. But if it be washed with an infusion of galls, and suffered to remain some time in the light, the letters obliterated will be so far restored, that they may be copied by a patient and practised decipherer, who is gifted with good vision. In those cases where the erased letters were originally written in a bold large hand,—and such are the characters of the more ancient manuscripts,—the task of deciphering them will of course be less troublesome, and the results obtained more certain. It appears, also, that the method of writing employed in ancient times has been found favourable to the restoration of works which had, to all appearance, been entirely obliterated.

[2] The *Codex Ephrem*, formerly numbered 1905, is now 9 in the *Bibliothèque du Roi*.

[3] "Fragmenta versionis Τῶν ὁ, a nemine adhuc (1785), quod sciamus, collata esse, mirum profecto videri debet omnibus, qui tam vetustarum membranarum excellentiam norunt." (*Symb. Crit.* i. p. 4.)

[4] *Palæographia Græca*, pp. 213, 214.

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lated the whole Scriptures into the language of that country, for which he also invented a new character, consisting of letters borrowed chiefly from the Greek. This work, however, had long been lost, with the exception only of the part containing the four gospels, which is preserved in the University Library at Upsal, in a manuscript called *Codex Argenteus*, from being written chiefly in letters of silver. But in the year 1755, F. A. Knittel, having been appointed archdeacon of Wolfenbuttel, began to explore the treasures contained in the Augustan Library in that city; and, in the course of his researches, a palimpsest manuscript of the *Origines* of Isidorus was pointed out to him, as containing, under that writing, the translation of the Epistle to the Romans by Ulphilas. On examination, it proved that the manuscript in question did not contain the whole epistle, but only a portion of the latter part, viz. the eleventh and following chapters, as far as the thirteenth verse of the fifteenth, accompanied by a Latin version written in parallel columns. Knittel immediately set himself to work on this curious fragment; and although, from the state of the leaves to be deciphered, the difficulty of the task was great, yet his zeal carried him through, and towards the end of the year 1758 he announced the intended publication by subscription. Various obstacles, however, retarded its appearance till the year 1762, when the laborious decipherer was enabled to publish the whole in quarto, with twelve large plates, a circumstantial account of the manuscript, and copious illustrations of its contents.[1] The diligence of Knittel omitted nothing that could render useful the recovered fragments, of which there were several. That of Ulphilas, in particular, he carefully compared with the *Codex Argenteus*, at Upsal, and ascertained that the latter did not form part of the same, but only of a similar manuscript. From the different fragments he extracted all the various readings; and, in his ample commentary, he indulged every reasonable desire of literary curiosity. He also subjoined an account of other palimpsest manuscripts in the same library, by which it appears that printed books were, in the early times of the art, sometimes worked off on vellum from which ancient writings had been erased; and he instanced particularly an edition of the Clementine Constitutions, printed by Nicolas Janson, in 1476, upon parchment which had undergone this process of obliteration to prepare it for the purpose.

In the work of deciphering palimpsest manuscripts Knittel was followed by Paul James Bruns, the coadjutor of Dr Kennicott, in his great work of Hebrew collation. In 1773, this person discovered, at Rome, a fragment of the ninety-first book of Livy, in a rescribed manuscript of the Vatican collection; and, in the same year, it was published by the discoverer himself at Hamburg,[2] and by Signor Giovenazzi at Rome. The fragment in question, which has been admitted as undoubtedly genuine into the later editions of Livy, contains part of the war with Sertorius in Spain; and the only subject of regret is, that this part is so small. Bruns first visited the Vatican on a mission from Dr Kennicott in reference to Hebrew collation; but having been thus fortunate in the investigation of a palimpsest, he renewed the inquiry in this country, and endeavoured to ascertain the number of such manuscripts in the Bodleian Library at Oxford. An account of his researches will be found in the Literary Annals of Helmstadt, which appear to have been conducted by Bruns during the years 1782, 1783, and 1784.

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But, notwithstanding these encouraging successes, no other publication of the same nature appeared until the year 1801, when Dr Barrett of Trinity College, Dublin, produced an elegant and accurate volume containing a great part of the gospel of St Matthew, copied from a rescribed manuscript in the library of that college; and this palimpsest appeared to have been re-written in the twelfth or thirteenth century, upon portions of much more ancient books. The most important of these, however, was the portion which contained the copy of St Matthew's gospel, whereof this fragment remained, written in uncial letters; and, judging by the usual marks of antiquity, it appeared to belong at least to the sixth century. A part of Isaiah in Greek, and some of the Orations of Gregory Nazianzen, were likewise found in it, but were considered as of less moment. What remains of St Matthew's gospel Dr Barrett published, with great accuracy, on sixty-four engraved plates, each representing a page of the manuscript, and containing from twenty-one to twenty-three lines, disposed in a single column. This valuable fragment commences with part of the genealogy, at verse 17, chapter i. and extends, with occasional chasms, to chapter xxvi. verse 71; and it is also represented in an equal number of pages, printed in the ordinary Greek character. Copious Prolegomena are prefixed, giving an exact account of the state and characters of the manuscript; and subjoined is a careful collation of the *Codex Montfortianus*, in the same library, with Wetstein's edition.[3] This publication, however, appeared too late to be used by Griesbach, whose second edition of the New Testament was published in the year 1796.

It remained, however, for another distinguished labourer in the new and interesting field of inquiry, which had thus been indicated rather than explored, to surpass all his predecessors and contemporaries, not only in discovering rescribed manuscripts, but also in extracting from them works or parts of works, which were long considered as irrecoverably lost. We allude, of course, to Signor Angelo Maio, formerly keeper of the Ambrosian Library at Milan, afterwards librarian of the Vatican, and now (1838) cardinal secretary; whose researches in this department have been so extensive and important, that he may truly be called the hero of palimpsests, and the discoverer of a new world of letters. It was not till the year 1814 that Monsignor Maio made himself known by the partial recovery of lost works. A year earlier, indeed, he had employed himself in translating a large portion of the oration of Isocrates, *De Permutatione*,[4] which Mystoxides, a learned Greek, had published from a manuscript in the Ambrosian Library, more perfect than any of the *codices* which had been followed by the editors of Isocrates. The quantity thus inserted in the oration increased it by at least one half; and the same additional matter has since been found in some of the Vatican manuscripts. In publishing this translation, however, Maio modestly continued anonymous. But his name was destined to be soon illustrated by far more important labours.

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[1] The manuscript of Isidorus, consisting of 330 leaves, contained portions of several older books, two of which, supposed to be of the sixth century, exhibited large fragments of the gospels in Greek. Several leaves had belonged to other works, but of these some could not be deciphered, whilst the others contained nothing to recompense the labour, excepting a fragment of the works of Galen. To these several remains, of different dates, he assigned distinctive names, classing them as separate *codices*. The fragments of the gospels he also printed entire. But the remains of the version of Ulphilas constitute the principal part of the volume, and are given with the most minute exactness. This part, however, occupied only four leaves of the manuscript of Isidorus; the other legible remains extending to 208 leaves out of the 330, so that 118 altogether defied the labour and skill of the decipherer.

[2] Saxius, *Onom.* viii. 263.

[3] This work is altogether most creditable to the industry, learning, and accuracy of the editor, Dr Barrett, and also to the University of Dublin, by which the expense of the impression was defrayed.

[4] Περὶ τῆς ἀντιδοσιως.

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1. His researches amongst palimpsest manuscripts commenced with certain hitherto unpublished fragments of three orations of Cicero, namely, those for Scaurus, Tullius, and Flaccus. These orations had been written in a quarto form, but had been partly erazed and folded into an octavo size to give place to the sacred poetry of Sedulius. The newer writing was judged to be as old as the eighth century, and the original to be not later than the second or third. The manuscript had belonged to a very ancient monastery at Bobium, or Bobbio, in the Milanese, founded by St Columban, who had also formed its library; and in the collection obtained from the same venerable institution, the greatest part of the rescribed manuscripts has been discovered. "In examining carefully some manuscripts in the Ambrosian Library at Milan," says Maio, in his preface, "I observed that one of great antiquity was a palimpsest. This manuscript had belonged to the convent of Bobbio, a monastery in Liguria, situated in the midst of the Apennines, which was founded by St Columban in the year 612, and the monks of which obtained considerable reputation for learning as well as sanctity. Gerbert, a Frenchman by birth, who became pope under the name of Silvester II., and attained so much celebrity for learning that he is one of those who are reported to have sold their souls to the devil, was head of this monastery in the tenth century, and added greatly to the reputation of the place, as well as to the contents of the library. The cardinal Frederic Boromeo, who founded the Ambrosian Library at the beginning of the seventeenth century, purchased the principal part of the collection at Bobbio, and brought it to Milan. Whilst I was examining these manuscripts," he adds, "I remarked that one, which contained some of the writings of Sedulius, a Christian poet, was a palimpsest; and on looking very closely and attentively, I discovered traces of the former writing under the latter." He then read the titles, *pro Scauro*, *pro Tullio*, and *pro Flacco*, and was able, with some trouble, to decipher the whole of the fragments of these three lost orations, written in large and very beautiful characters, each page being divided into three columns.[1] The oration for Scaurus was accompanied by *scholia*, elegantly written in small letters of a square form; and there were others in characters of a ruder form, but still ancient. These three fragments, together with the scholia (which Maio considers the production of Asconius Pedianus), were published at Milan, 1814, in one volume 8vo.

2. In the course of the same year, Monsignor Maio produced a second volume, containing various fragments of three other orations of Cicero, with some ancient annotations and commentaries never before published. The portions thus recovered belonged to the orations against Clodius and Curio, to that *De Ære alieno Milonis*, and to the oration *De Rege Ptolemæo*.[2] These treasures had lain concealed under a Latin translation of the Acts of the Council of Chalcedon, and were adjudged by the discoverer to belong to the fourth century. The palimpsest from which they were discovered had formed part of the collection obtained from Bobbio. The older writing was in very large and handsome characters, but less beautiful than that which contained the fragments of the three orations mentioned in the preceding paragraph; and there were only two columns in each page, a circumstance which seems to indicate that the writing is somewhat less ancient. The contents of these two volumes the learned editor afterwards united into one, which he published in 1817, with corrections of the fragments that had first appeared, and some additional notes and illustrations.[3] The great antiquity of the practice of rescription is sufficiently attested by these various fragments of Cicero's orations; indeed it is supposed that the speech for Scaurus was obliterated in the eighth century. But Latin manuscripts appear to have been more frequently subjected to this treatment than Greek manuscripts. The former are found to have undergone rescription at a date as remote as the seventh century; but of the latter not one has been met with in which the second writing seemed older than the eleventh century. With regard to the manuscripts from which the fragments above mentioned were recovered, Maio assures us that, in both, the ancient writing was as much superior to the modern, as the matter it contained was more precious; that, in fact, the form and the substance were both more excellent.[4]

3. The year 1815 proved very rich in discovery, and gave birth to no less than three volumes of unpublished works. One of these is peculiarly valuable and curious, as containing large portions of several orations of Symmachus, in whom, as Maio expresses it, breathed the last inspiration of Roman eloquence. The epistles of this famous orator were the only productions of his pen previously extant; but in these recovered fragments we have a copious specimen of his eloquence in two panegyrics on Valentinian, one on Gratian, a gratulation addressed to the father of the orator on his being appointed consul, and parts of several other works of the same kind, making eight in all. Maio likewise deciphered a portion of a panegyric of the younger Pliny, which was contained in the same palimpsest, but of which only the various readings are here given. The original manuscript is supposed to have belonged to the seventh or eighth century. These interesting fragments were reprinted at Frankfort in 1816, in one volume 8vo.

4. The same year another very ancient palimpsest was found in the Ambrosian Library, containing all the comedies of Plautus which have reached us, except four; and a fragment of the *Vidularia*, a lost comedy, of which all that previously remained consisted of about twenty lines, preserved by Priscian and Nonius. The ancient writing in this manuscript is exceedingly beautiful, and is supposed to be of the time of the Antonines; the more modern, consisting of part of the Old Testament in Latin, is conjectured to be of the seventh century. Maio deciphered a number of various readings, together with about sixty inedited lines belonging to the different comedies; and restored the following spirited lines of the *Stichus* (act i. sc. 5), which had previously existed in an imperfect state:

> Famem fuisse suspicor matrem mihi,
> Nam postquam natus sum, satur nunquam fui;
> Neque quisquam melius referet matri gratiam,
> Quam ego matri meæ retuli invitissimus.

This, therefore, is an important discovery, not so much on account of what has actually been recovered, as by reason of the expectations which it is calculated to encourage.

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[1] The delight of the learned librarian on making this discovery knew no bounds. "O Deus immortalis, repente clamorem sustuli, quid demum video? En Ciceronem, en lumen Romanæ facundiæ, indignissimis tenebris circumseptum! Agnosco deperditas Tullii orationes; sentio ejus eloquentiam ex his latebris divina quadam vi fluere, abundantem sonantibus verbis uberibusque sententiis." (*Præf.*)

[2] For the *first* and *third*, see the fragments of Cicero, numbered "*Orat.* 15, 16," in Ernesti's edition. But of the *second*, namely, that *De Ære alieno Milonis*, no fragment existed anterior to the discovery of Maio.

[3] This edition is entitled, "M. Tullii Ciceronis sex orationum partes, ante nostram ætatem ineditæ, cum antiquo interprete, qui videtur Asconius Pedianus, ad Tullianos septemtriones. Accedunt scholia minora vetera." Milan, 1817, 8vo.

[4] Of the more modern matter the learned editor observes, "Sed enim et illud fatendum est plerosque palimpsestos Christiana argumenta, immo ipsos divinos libros excepisse, quorum materiam, quanquam religionis gratia exosculamur, eam tamen vacuas membranas multo mallemus occupâsse."

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For if Monsignor Maio found a Latin Bible containing almost an entire copy of Plautus, it cannot be affirmed that any classical author is irrecoverably lost until every Bible in manuscript, and every other writing upon ancient parchment, has been diligently examined. There is no moment at which some important discovery may not be made, provided the labour of scrutinizing parchments be persevered in. That there are many palimpsests in the public libraries of Great Britain, particularly in the Bodleian at Oxford, which is singularly rich in manuscripts, can scarcely admit of a doubt. The number of manuscripts in Spain, and her vast mass of archives, have long been equally famous; nor is it impossible that several lost works, or portions of works, by Latin authors, may yet be found in that country. Although the search for manuscripts that are directly and obviously valuable may have proved fruitless, yet a very different result may follow when parchments are examined with a view to ascertain whether a lower stratum of writing exists beneath the sterile surface, and whether some of the most precious remains of ancient genius and eloquence may not be covered or concealed by the rubbish of chroniclers and ecclesiastical writers. Great as was the destruction which took place at the Reformation,[1] enough still remains to warrant the conviction, that were there more Maios to examine and decipher palimpsest manuscripts, there would be numerous additional and most important discoveries. Who knows but that, in the most paltry and unpromising volume, may be found the works of the most eloquent of historians; that

Pellibus exiguis arctatur Livius ingens?

5. The next discovery effected by Maio, from a manuscript of the same class, was that of the remains of the orator Fronto, who had flourished in the reign of Hadrian. This writer, though by birth an African, was in his day esteemed almost a second Cicero; yet of his writings little more remained than a few scattered sentences, preserved in the works of other authors. Maio, however, by his acuteness and perseverance, was enabled to recover a very considerable portion of Fronto's works, which he published at Milan in 1815, in two vols. 8vo, under the title of *M. Cornellii Frontonis Opera inedita, cum Epistolis item ineditis Antonii Pii, M. Aurelii, L. Veri et Appiani, necnon aliorum veterum fragmentis.*[2] The contents of the first volume consist of one book of epistles addressed to Antoninus Pius, two books to Marcus Aurelius, and two to Lucius Verus; two books of letters to friends; several letters addressed to Marcus Aurelius, on the subject of the *Feriæ* at Alsium, a town in Etruria; and one to Lucius Verus, in which the orator laments the death of his grandson, one of the children of his son-in-law Victorinus. The second volume exhibits a considerable portion of two books, *De Orationibus*, addressed by Fronto to Marcus Aurelius; parts of various orations and epistles; and also a portion of an address to Antoninus, entitled *De Bello Parthico*, consoling him for the reverses experienced in the Parthian war. Then follow some important fragments under the title of *Principia Historiæ;* a few playful prolusions on lighter subjects; and a book of epistles written in Greek. The work is concluded with a collection of all the fragments of Fronto's works which have elsewhere been preserved, and with copious illustrations of those which were then for the first time published. In the palimpsest from which these curious remains were deciphered, the more recent writing formed part of the Council of Chalcedon; but the manuscript was unhappily much damaged, and altogether in a very imperfect state. Fronto was a voluminous writer, and composed works upon various subjects, amongst which was an Invective against the Christians. He had a great reputation as an orator, and was accounted the Cicero of his time; although his style, which is said to have united the *siccum* and the *grave*, does not very well accord with such a distinction. The writings of so remarkable a person, however, would, in any circumstances, be an object of interest; but they become doubly curious from having been thus marvellously brought to light.

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6. In the mean time, Maio was preparing another publication of similar origin, which, in 1816, he gave to the world, under the following title, viz. *Interpretes Veteres Virgilii Maronis; Asper, Cornutus, Haterianus, Longus, Nisus, Probus, Scaurus, Sulpicius, et anonymus; e Veronensi palimpsesto.* We have not met with any account of the Verona palimpsest here mentioned; but the work consists of previously inedited fragments of all the commentators enumerated in the title. A palimpsest manuscript, however, which soon afterwards engaged the attention of Monsignor Maio, enabled him to make most important additions to the discovery of Knittel already described; namely, that of the Gothic version of Ulphilas. This manuscript belonged to the Ambrosian collection, and from it Maio published, in 1820, *Ulphilæ Interpretatio Gothica, in Ambrosiano palimpsesto detecta, epistolarum tredecim Divi Pauli, aliarumque partium aliquot Biblicarum, Esdræ nimirum, Nehemiæ, Divi Matthiæ, cum anonymi Homilia, seu Tractatu, et cum parte Gothici calendarii.* Not having seen this work, however, we are unable to give any particular account of it, or to specify the various important additions which it is understood to have made to the discovery of Knittel.

7. Maio now entered upon a more enlarged and important scene of action. His distinguished merit in this new field of discovery having obtained for him the notice of Pius VII., he was, by that pontiff, appointed keeper of the Vatican Library, and speedily justified this preferment by a discovery more interesting and valuable than any which he had hitherto made. In a palimpsest volume, which had formed part of the manuscript collection originally brought from Bobbio,[3] and which contained, in the exterior writing, part of the commentary of St Augustin on the Psalms, he found

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[1] In the Protestant parts of Europe the most frightful havoc was committed at the Reformation. Huge volumes containing the ancient services abounded in all the churches and monasteries. Most of these had been brought directly from Rome; and in the days when books of this kind were transcribed, it must have been considered as an act of piety to erase almost any writing whatever, to make way for the sacred offices. From the very nature of these books, indeed, there can be little doubt that much *ancient* parchment entered into their formation; and as they were carefully preserved, exempt from accident or injury, there can be little doubt that in many, perhaps in most of them, there existed under the rescription the remains of more ancient writings. Yet, wherever they could be found, they were consigned to the flames without mercy, in virtue of enactments which enjoined the destruction of all popish books; and inestimable chances of discovery were thus for ever lost to the world.

[2] This work, like a former one, was reprinted at Frankfort, in the year 1816.

[3] The history of the manuscript which contained these precious remains may be very shortly stated. It originally belonged to the famous monastery at *Bobium*, and was purchased by Paul V. more than two centuries ago, with the knowledge that it was a palimpsest, and contained part of Cicero's treatise *De Republica;* though, by some strange neglect, it was reserved for Maio to bring its contents to light. From the same original library most of the other manuscripts at Milan and Turin were also purchased. This library, as well as the monastery, was founded by the famous Irish saint, Columbanus, in the beginning of the seventh century; and most of the manuscripts, from which remains of ancient authors have been recovered, are inscribed, in a very old handwriting, *Liber Sancti Columbani de Bobio.*

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that the interior or more ancient writing had consisted of the long-lost books of Cicero *De Republica*, the most celebrated of all his works, and of which nothing had been known, in modern times, beyond the fragments preserved in the writings of Macrobius, Lactantius, Augustin, Nonius, and others. The manuscript was in excellent order; the characters were large and plain; and, in the leaves which remained, there was scarcely a page that could not be deciphered; but many of the pages were wanting. And there seemed reason to apprehend that the same deficiency would often occur in future discoveries, because the work last inscribed might not have been co-extensive with the original writing obliterated, and because, when the volume had been taken to pieces for the purpose of rescription, the whole of the leaves that contained the original writing might not have been put together again, but some of them applied to other purposes, and leaves taken from other works, or of new parchment, inserted in their place. But however this may be, in these invaluable pages a very considerable part of the first and second books of the celebrated treatise in question was found so perfect as to be completely recovered by the labour and sagacity of Monsignor Maio. The portions of the work thus rescued from oblivion were published at Rome in 1821,[1] with copious notes and illustrations, particularly an accurate account of the various chasms occasioned by the loss of original leaves, and accompanied with such a restoration of the four remaining books as could be effected from the less perfect portions of the manuscript, and the various fragments preserved by Sigonius and other critics. A finer specimen of editorial skill, learning, and sagacity, is nowhere to be found.

The part of this important treatise which has thus been unexpectedly brought to light, is amply sufficient to give a clear insight into the plan and style of the dialogues, as well as into the characters of the various interlocutors, under whose names the illustrious author chose to develope his own opinions. These were, the second Scipio Africanus, and his friend Lælius; L. Furius Philus; M. Manilius, whom Cicero elsewhere praises for his knowledge of the law; Sp. Mummius, the brother of Mummius Achaicus; Q. Ælius Tubero; P. Rutilius Rufus; Q. Mucius Scævola; and C. Fannius, son-in-law of Lælius. The introduction to the first book is nearly complete; but that which stamps the highest value on the work is the luminous philosophy of the author on the subject of government and policy, as expounded by Scipio, the principal interlocutor, with unrivalled eloquence and felicity of expression. We now understand the grounds upon which the ancients preferred this to all Cicero's philosophical works; and, on the whole, notwithstanding its still imperfect state, it is unquestionably one of the most interesting acquisitions that have been made, in the department of classical literature, since the original publication of the ancient authors, soon after the revival of letters. May we not indulge the hope that, ere long, some important additions will be made to the invaluable fragment which Maio has so laboriously and skilfully brought to light?[2]

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8. The zeal and the industry of Maio did not relax from success. On the contrary, soon after the appearance of the fragment of Cicero's treatise *De Republica*, he gave to the learned world another elaborate publication, containing, 1. Juris Civilis Antejustinianei Reliquia inedita; 2. Symmachi Orationum partes; 3. C. Julii Victoris Ars Rhetorica; and, 4. L. Cæcilii Minutiani Apulei Fragmenta de Orthographia. These remains were also recovered from a rescribed manuscript in the Vatican Library, and were, as usual, accompanied by notes, appendices, and illustrative plates. In the preface to this work, the learned editor expresses his unabated enthusiasm in exploring and deciphering the palimpsest manuscripts of the Vatican collection: "Pergo alacriter," says he, "rescriptos Vaticanæ Bibliothecæ codices, pro meæ stationis munere, ad publicum commodum explicare." The praises due to his alacrity, as well as to his sagacity and perseverance, will not certainly be denied, nor even grudgingly awarded, by those who are capable of appreciating the full extent and importance of his long-continued labours in this interesting department of literary investigation.[3]

The example of this extraordinary success could scarcely fail to excite the curiosity and stimulate the diligence of the learned; and, accordingly, another labourer of high qualifications soon entered the same field of inquiry. The library of the Chapter of Verona had long been famous for the number of the manuscripts contained in it; and it was also known to be remarkably rich in those which related to jurisprudence. In the *Verona Illustrata* of Maffei, published in 1732, the author had given an index to all the manuscripts, and particularly mentioned several leaves of parchment, some of which treated of Prescriptions and Interdicts, whilst others contained fragments of the Pandects, and part of the work of an ancient jurisconsult; "quai codici, se si fossero conservati, niente si ha in tal genere, che lor si potesse paragonare." The leaves in question were afterwards bound up in a small volume, composed of fragments of different manuscripts; and extracts from both were published by Maffei, with a fac-simile of the characters, in his *Istoria Teologica*. But these curious relics attracted little attention, or rather were altogether forgotten, until the successful researches of Maio had awakened and animated the curiosity of the learned. In the year 1816, however, Haubold revived the recollection of them by printing at Leipzig a treatise entitled *Notitia Fragmenti Veronensis de Interdictis;* which appears to have attracted considerable notice. In the same year, Niebuhr, passing through Verona on his way to Rome, as Prussian envoy to the court of the Vatican, visited the library of the Chapter, and, during two days which he passed at Verona,

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[1] The work, as stated in the text, was published at Rome, with a grateful dedication to Pius VII. to whom Maio had been indebted, not only for his preferment, but also for numerous other acts of kindness and favour. It was also republished at London, 1823, in one vol. 8vo.

[2] In proof of the great antiquity of the practice of obliterating one writing to make room for another, Maio, in the learned preface to his edition of the dialogue *De Republica*, cites part of a letter from Cicero to Trebatius, which is conclusive on the point. "Ut ad epistolas tuas redeam, cætera belle....nam quod in Palimpsesto, laudo equidem parsimoniam; sed miror quid in illa chartula fuerit quod delere malueris quam hæc non scribere, nisi forte tuas formulas. Non enim puto te meas epistolas delere, ut reponas tuas. An hoc significas, nihil fieri? frigere te? Ne chartam quidem tibi suppeditare?" (*Ad Familiares*, vii. 18.) The learned editor further informs us, that he had only met with palimpsest *parchment*, and that *paper* of every kind seemed to be unfit for such a purpose.

[3] To do full justice to the merits of Monsignor Maio, it would be necessary to expatiate upon several learned and elaborate works, which, within the same period, his unexampled industry produced, from very different sources. As specimens of these, we shall mention only two, viz. 1. The splendid folio volume of fragments of the Iliad, with ancient illustrations, elegantly copied in outline, and unpublished scholia on the Odyssey, from a most valuable manuscript in the Ambrosian Library; to which are prefixed large and important *prolegomena:* and, 2. The Latin edition of the Chronological Canons of Eusebius, in two books, the first of which had been wholly lost to the western world, until it was recovered by Maio from an Armenian manuscript. In the latter work the editor had the valuable assistance of Dr Zohrab, a very learned Armenian. These and other works, a list of which will be found at the end of his Homer, may serve to show that, difficult and laborious as the task of deciphering palimpsest manuscripts may appear, it does not so exhaust the energies of an active mind, as to prevent the successful pursuit of other learned inquiries and researches.

Palimpsests.

took an accurate copy of the fragment *De Præscriptionibus et Interdictis*, and also transcribed another, *De Jure Fisci*. But if this had been all, the labours of these two days, however meritorious, would perhaps have soon been forgotten. Fortunately for letters, however, he examined another manuscript, then numbered xiii., and found that the exterior writing contained some epistles of St Jerome, whilst a more ancient writing appeared underneath. On further examination Niebuhr perceived that the latter contained the work of some ancient jurisconsult; and having applied the infusion of galls to folio 97, he so far restored the characters as to be able to transcribe the portion of the original text therein contained. He then communicated his discovery to Savigny, and, with the assistance of the latter, published, in a periodical work, the specimen transcribed, accompanied with an ingenious commentary, in which he maintained that the manuscript referred to contained the Institutions of Gaius, and that the fragment *De Præscriptionibus et Interdictis* formed part of that work.

The result fully established the soundness of this conclusion. Two other labourers were therefore sent by the Berlin Academy of Sciences to work the mine which Niebuhr had thus happily opened; and having obtained the permission of the Chapter, they transcribed the manuscript almost entirely, only about one ninth part of the whole, or rather less, being found illegible. The transcript was immediately submitted to the academy, and the Institutions of Gaius first appeared at Berlin in the year 1820.[1] The manuscript from which this invaluable relic of ancient jurisprudence was recovered consists of 127 leaves. The more recent writing, which is in uncial characters, and of considerable antiquity, contains some of the works of St Jerome, chiefly his epistles, of which there are twenty-six. The more ancient is of two kinds; the one remarkable for its antiquity and elegance, and the other intermediate, that is, written *over* the first, and *under* the third or last writing The former of these is that in which the Institutions of Gaius were written; so that the intermediate kind had superseded the work of the Roman jurisconsult, but had, in its turn, yielded to the third and last writing. As to the age of the original manuscript, Niebuhr very early expressed an opinion that it was older than the time of Justinian; and Kopp, judging from the forms of the letters, the contractions, and various other indications, arrived at the same conclusion. It is creditable to the literary curiosity of Germany that the first edition of this work was almost immediately sold off. Bluhm, who had been concerned in the first transcription, paid another visit to Verona, where he re-examined the manuscript with great care; and the fruits of his labour appeared in the second edition, which was published in 1824. In the following year, a third edition appeared at Leipzig, without the notes of Goeschen, and with the modern instead of the ancient orthography, which had been religiously retained in the two Berlin editions. Gaius was somewhat late in attracting attention in France, where learned lawyers were once so abundant; but the translation of M. Boulet had the effect of partially awakening the curiosity of his countrymen, by rendering this invaluable relic of Roman jurisprudence more easily and generally accessible.[2]

The history of such extraordinary successes in deciphering palimpsest manuscripts ought surely to excite the emulation of scholars in other parts of Europe, where large collections are deposited, and lead them to examine whether, in many of these, similar materials may not be found. Knittel aptly denominates his rescript of various contents another Herculanum; and, in fact, more of importance has already been recovered from this class of manuscripts than from all the half-consumed volumes obtained from that once promising repository. Every information that may be wanted as to the true mode of examining and deciphering such manuscripts, will be found in the learned prefaces of Knittel, Barrett, and Maio; with much to encourage scholars to engage in the same pursuit, unless perchance their ardour be cooled by the prospect of the severe and unremitting labour which is indispensably necessary to ensure success. It should also be remembered, that the Latins commenced the practice of rescription as early as the sixth or seventh century, and continued it not only till the invention of printing, but even after that period; and that, making every allowance for the destruction which took place at the Reformation, the number of palimpsests still in existence must, beyond all question, be very great. All that is wanted, therefore, to ensure further acquisitions, is labour and research, united with patience and ordinary sagacity. By what has already been achieved, we are, so to speak, placed upon a vast plain, which has no defined limits; and although the horizon may seem to our senses to circumscribe the prospect, yet, on whichever side we advance, the apparent obstacles vanish, and our view still continues as extensive as before. (A.)

Palindromus ‖ Palinurus.

PALINDROMUS, a verse or sentence which runs the same when read either backwards or forwards. Such is the verse,

Roma tibi subito motibus ibit amor.

Some people of leisure have refined upon the palindromus, and composed verses, each word of which is the same read backwards as forwards; for instance, that of Camden:

Odo tenet mulum, madidam mappam tenet Anna.
Anna tenet mappam madidam, mulum tenet Odo.

PALINGENESIA, amongst divines, the same with regeneration. Amongst the older chemists, it denotes the producing of a body from its principles.

PALINGENIUS, Marcellus, an Italian poet, well known by a poem divided into twelve books, and entitled *Zodiacus Vitæ*, which occupied him several years in composing, and dedicated to Hercules II. of Este, duke of Ferrara. Some say he was a physician to that prince; others rank him amongst the learned Lutherans, to whom the Duchess of Ferrara gave a reception in her court, and honoured with her protection. His Zodiac contains good things, and is a philosophical satire against immorality and false prejudices. Of the author's life, however, little is known. He died some time between the years 1537 and 1543.

PALINODE, a discourse contrary to principles formerly avowed; and thence the phrase of *palinodiam canere* means a recantation.

PALINURUS, in fabulous history, the pilot of Æneas, whose fate Virgil very pathetically describes. He fell into

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[1] Gaii Institutionum Commentarii iv. e codice rescripto Bibliothecæ Capitularis Veronensis, a Frid. Bluhmio iterum collato secundum edit. J. F. L. Goeschen. Accedit Fragmentum veteris Jurisconsulti de Jure Fisci, ex aliis ejusdem Bibliothecæ membranis transcriptum. Berolini, 1824, 8vo. We have not met with the less perfect edition of 1820.

[2] Who was Gaius, and when did he flourish? This is a question which it has been found exceedingly difficult to answer. From a number of circumstances, however, it has been conjectured that he was born under Hadrian, that he began to write about the end of the reign of Antoninus Pius, that he attained the summit of his celebrity under M. Aurelius, and probably died under Commodus. "Scripsit autem ille, *quisquis fuerit*, Institutiones," says Gravina, "unde suas magnam in partem depromsit Justinianus;" and Justinian himself, in speaking of his own Institutions, thus acknowledges his obligations to Gaius: "Quas, ex omnibus antiquarum institutionibus, *et præcipue ex Commentariis Gaii nostri*, compositus," &c.

Palisse, La ‖ Palladium.

the sea when asleep, and was three days exposed to the tempests, but at last got safe ashore, when the cruel inhabitants of the place murdered him to get his clothes. His body was left unburied on the sea-shore; and since no one could cross the Stygian lake before a hundred years were elapsed, if his remains had not been decently interred, we find Æneas, when he had descended to the regions below, speaking to Palinurus, and assuring him, that though his bones were deprived of sepulture, yet the place where his body was exposed should soon be adorned with a monument, and bear his name; and accordingly a promontory was called *Palinurus*.

PALISSE, La, an arrondissement of the department of the Allier, in France, extending over 597 square miles. It comprehends six cantons, divided into seventy-four communes, and contains 73,614 inhabitants. The capital is the city of the same name, situated on a fertile spot on the left bank of the river Allier. It contains 2286 inhabitants, who are employed in spinning cotton, and to a considerable extent in making boots and shoes.

PALKAH, a small town of the Sikh territories, in the province of Lahore, 112 miles north-east from the city of Lahore. Long. 75. 13. E. Lat. 32. 58. N.

PALK'S Straits, an arm of the sea, which separates Ceylon from the coast of Coromandel.

PALL, in *Heraldry*, a figure like a Greek γ, and about the breadth of a pallet. It is by some heralds called a *cross pall*, on account of its being looked upon as an archiepiscopal bearing.

PALLA, in Roman antiquity, a mantle which women wore over the gown called *stola*. It was borne on the left shoulder, whence passing to the other side, under the right arm, the two ends were bound under the left arm, leaving the breast and the arm quite bare. It had a great many folds, and derived its name from $\pi\alpha\lambda\lambda\omega$, *to shake* or *tremble*.

Palla *Isle*, a small island in the Eastern Seas, about six miles in circumference, situated to the south of Sangir. Long. 125. 30. E. Lat. 3. 5. N.

PALLADIO, Andrea, a celebrated Italian architect, was born at Vicenza in 1518, being descended of a family originally of Friuli. The celebrated Trissino was his friend and Mæcenas. He made exact drawings of the principal works of antiquity in Rome, adding commentaries, which went through several impressions. But this, though a very useful work, was greatly exceeded by his Treatise of Architecture, in four books, which appeared in the year 1570. On this work Inigo Jones wrote some excellent remarks, which were included in an edition of Palladio, published by Leoni in 1741, in two vols. folio. Palladio died at Vicenza, on the 19th of August 1580, in the sixty-second year of his age.

PALLADIUM, in *Antiquity*, a statue of the goddess Pallas, or Minerva. It was about three cubits high, and represented the goddess sitting, with a pike in her right hand, and in her left a distaff and a spindle. However various the opinions of ancient authors be about this celebrated statue, it is universally allowed that on its preservation depended the safety of Troy. This the Greeks, during the Trojan war, were well aware of; and therefore Ulysses and Diomedes were commissioned to steal it. They effected their object; and if we may rely upon the authority of some, they were directed how to carry it away by Helenus, a son of Priam, who in this betrayed his country, because his brother Deiphobus, on the death of Paris, had married Helen, of whom he was enamoured. Minerva was enraged at the violence offered to her statue. According to Virgil, the palladium itself seemed to have received life and motion; and by the flashes which darted from its eyes, and its sudden springs from the earth, it seemed to evince the resentment of the goddess. According to some, however, the true palladium was not carried away from Troy by the Greeks, but only a statue of similar size and shape, which was placed near it, to deceive any sacrilegious persons who might attempt to steal it. They maintain, therefore, that Æneas conveyed the palladium safely from Troy to Italy; and that it was afterwards preserved by the Romans, with the greatest secrecy and veneration, in the temple of Vesta, a circumstance which none but the vestal virgins knew of. It was esteemed the destiny of Rome; and there were several others made perfectly like it, to secure it from being stolen, like that of Troy, which the oracle of Apollo declared would never be taken as long as the palladium was found within its walls. A palladium was also placed by Nicias in the citadel of Athens.

Palladius ‖ Pallas.

PALLADIUS, bishop of Helenopolis in Bithynia, and next of Aspona. He was a Galatian, and born at Cappadocia. He became an anchorite in the mountain of Nebria in 388, and was consecrated bishop in 401. He was an intimate friend of St John Chrysostom, whom he never forsook during the time of his persecution, nor even in his exile. He went to Rome some time after Chrysostom's death, and, at the request of Lausus, governor of Cappadocia, composed a history of the anchorites or hermits, which he entitled *Lausiaca*, after the name of Lausus, to whom it was dedicated. This took place in the year 420, when the book was written; the author being then in the twentieth year of his episcopacy, and fifty-third of his age. Palladius was accused of being an Origenist. It is true, he was an enemy to St Jerome, of whom he does not speak well, and was intimately connected with Ruffinus; but perhaps no good proof can be brought of his Origenism. He had been the disciple of Evagrias of Pontus, and was even suspected of entertaining the sentiments of Pelagius. He died in the fifth century, but in what year is not certain. His history was published in Greek by Meursius, at Amsterdam, in 1619, and in Latin in the *Bibliotheca Patrum*; but he seems not to have been the writer of the Life of St John Chrysostom in Greek and Latin, printed in 1680.

PALLANZA, a province of the principality of Piemont, in the continental part of the kingdom of Sardinia. It is bounded on the north by Domo d'Ossola, on the east by Lago Maggiore, on the south by Novara, and on the west by Val di Sesia. It extends over 506 square miles, contains 135 towns and villages, fifty-six hamlets, and 115,000 inhabitants. It is in the north mountainous, in the south undulating, but very generally picturesque, especially on the eastern side, near the Lake Maggiore, which is adorned with the Borromean Islands. It is productive of fruit, tobacco, chestnuts, and wine; but does not grow quite sufficient corn for the consumption of its dense population, who are frequently compelled to wander to other districts to seek employment and subsistence. The capital is the small city of the same name situated on a point of land running into Lago Maggiore, on which it has a harbour for small craft. It contains two churches, a nunnery, a public school, and 1320 inhabitants.

PALLAS, Simon Peter, a distinguished naturalist and geographer, born on the 22d of September 1741, was the son of Simon Pallas, a surgeon in the Prussian army, and professor of surgery at Berlin.

He received the early part of his education in his father's house, and his instructors bore ample testimony to the rapidity of his progress. At the age of fifteen he began to attend medical lectures, and he applied himself so closely to practical anatomy, that in 1758 he was found qualified to deliver a course of public lectures on that science. In the same year he went to Halle, and became the pupil of Segner, continuing also his studies of zoology, and, in particular, of entomology, with great assiduity. In

Pallas. 1759 he removed to Göttingen, where he made a variety of experiments on poisons, and on other active medical substances, and commenced his observations on parasitical animals. In July 1760, he went on to Leyden, in order to attend the lectures of Albinus, Gaubius, and Muschenbroeck; and at the end of the same year he took his degree of doctor of physic. The following summer he proceeded to England, principally with the view of completing his medical education, although he devoted the greater part of his time to the active pursuit of natural history, being assisted and encouraged by the friendship of Peter Collinson, and of some other British naturalists, which procured for him a few years afterwards the distinction of having his name inserted in the list of the foreign members of the Royal Society, at the early age of twenty-three. He visited several parts of the coast of England, in order to examine its marine productions; and his love of natural history enabled him to profit in a similar manner by an accident which detained him for some time at Harwich, on his return to the Continent, in the spring of 1762.

Having paid a visit to his native city, he went again to the Hague, and established himself as a resident there under the patronage of Gaubius. On occasion of the publication of a miscellaneous work on zoology, which he dedicated to the Prince of Orange, he proposed a plan for an expedition to the Cape of Good Hope, and to the Dutch East Indies, which he offered to conduct in person; but although the project was encouraged by Gaubius, and approved by the prince, his father's interference prevented its execution, and obliged him to return to Berlin. His filial affection, however, was not strong enough to induce him to refuse the invitation of the Empress Catharine to St Petersburg, where he accepted, in the year 1767, the appointment of professor of natural history in the Imperial Academy of Sciences.

The first few months of his residence at St Petersburg were employed in preparing his Zoological Gleanings for publication, and in making catalogues of some collections of natural history. It was now that the more active career of his public life was about to commence; and in 1768 he undertook, in common with Falk, Lepechin, and Guldenstädt, the conduct of an expedition sent out by the empress, for the joint purposes of observing the transit of Venus, and of investigating the natural history and geography of Siberia, and the neighbouring countries. The object of their researches for the first summer was the province of Kasan, and the winter was passed at Simbirsk: the next year they examined the shores of the Caspian, and the borders of Calmuck Tartary; after which they returned through Orenburg, and passed the winter at Ufa. In 1770 Pallas crossed the Uralian Mountains to Catharinenburg, and, after examining the mines in that neighbourhood, proceeded to Tobolsk. The next year he went to the Altaic Mountains, traced the course of the Irtysch to Kolyvan, went on to Tomsk, and observed the natural freezing of quicksilver at Krasnoyarsk, on the Yenisei, in latitude $56\frac{1}{2}°$ north. He proceeded in March 1772 by Irkutsk across the Lake Baikal, as far as Kiatka, and returned to Krasnoyarsk. In 1773 he visited Tara, Astracan, and Tzaritzin, on the Volga, and returned to St Petersburg in 1774, after an absence of six years. About ten years later he was made a member of the Board of Mines, with an additional salary of L.200 a year; and he was complimented with the title of a knight of St Vladimir. The empress purchased his collection of natural history for a price one third greater than his demand, and allowed him, at the same time, to keep it in his possession for the remainder of his life.

In 1794 he took a journey into the Crimea, and was captivated with the beauty of the country and its productions; the climate also appearing to be such as his health was supposed to require, he obtained from his munificent patroness not only permission to establish himself there, but a grant of a large and fertile estate, and a sum of 10,000 rubles to assist him in his outfit. He was thus enabled to build a little palace rather than a country house, in which a traveller from the north of Europe was sure to receive the most obliging hospitality, as Dr Clarke has made well known to the English reader. It appears, however, that the air was not altogether exempt from the miasmata, which are the causes of paludal fevers; and some other circumstances, besides the distance from all civilized society, seem to have made the old age of Pallas more cheerless than he had anticipated to find it, in the independence and tranquillity of his patriarchal establishment at Akmetshet. About ten years after the period of Dr Clarke's travels, he undertook a journey to Berlin to pay a visit to his brother, and died there in September 1811. Pallas.

Linné the younger has given him a genus, *Pallasia*, in his *Supplementum Plantarum;* a compliment to which his unremitting labours, in every department of natural history, had amply entitled him. His collection of dried plants was purchased by Dr Clarke's fellow-traveller, Mr Cripps, and passed into the possession of Aylmer Bourke Lambert.

The general character of Professor Pallas's acquirements appear to have been that of extent and variety, together with fidelity. He was not the author of any new theories or improved systems; and it has sometimes been observed, as by Murray in his System of Vegetables, that his descriptions were somewhat defective, from the omission of correct specific distinctions; but this omission is of such a nature as to affect a compiler or a book-maker much more than an actual student of natural history who is studying for his own improvement only, and who is capable of entering into a detailed examination of the objects concerned. To such a detail the principal part of Professor Pallas's works have relation; and it is impossible to enumerate the whole of his memoirs without making a pretty extensive catalogue of the productions of the various kingdoms of nature.

1. His Dissertatio Inauguralis de Insectis Viventibus intra Viventia, 4. Leyden, 1760, containing a systematic account of intestinal worms, is said to have been previously published in another form at Göttingen, a short time before he went to Leyden. 2. We find in the Philosophical Transactions for 1763, p. 62, a short note On the Cold observed at Berlin the preceding winter. 3. In the volume for 1766, p. 186, a description of the jaculator fish, or Sciæna jaculatrix of the Indian Ocean, which catches insects by darting drops of water at them: this description is repeated in the *Spicilegia Zoologica*, fasc. 8. 4. Elenchus Zoophytorum, 8. Hague, 1766; containing nearly three hundred species; Dutch by Boddaert, with figures, 8. Utrecht, 1768. 5. Miscellanea Zoologica, 4. Hague, 1766; consisting of descriptions and dissections. 6. Spicilegia Zoologica, 4. Berl. 1767–1780. Of this valuable collection of memoirs, intended for the description and illustration of new or little-known species of animals, there appeared in the whole fourteen fasciculi; some of them were published by Professor Martin during the author's absence in Siberia. We find, amongst other articles, an interesting account of the musk-deer, of various species of the antelope, and on the different varieties of sheep, both wild and tame; the latter has been published in English, On Russian and Tartar Sheep, 8. Edinb. 1794. 7. In the *N. Act. Acad. Nat. Cur.* iii. p. 430, Phalænarum biga; an account of two species of moth, of which the females are without wings, and spontaneously fertile. 8. A variety of miscellaneous papers, by Pallas, appeared in the Stralsund Magazine, which began to be published at Berlin in 1767: they

Pallas. chiefly relate to the Winter Residence of Swallows, vol. i. p. 20; to Hydatids found in the abdomen of ruminant animals, and supposed to be a species of tænia, p. 64; to the Birds of Passage of Siberia, p. 145, from Heller's Notes; to Firmin's supposed discovery of the Origin of the Belemnite, p. 192; to some Peculiarities of Insects, p. 225; to a Poison supposed to be prepared in Siberia from the Sitta, or nut-hatch, p. 311; to the Elk or Moose-Deer, p. 382, from Heller's papers; and to the use of the Sphondylium in Kamtschatka, p. 411. 9. Collections relating to the Mongol Tribes, published in 1776, and showing that they are distinct from the Tartars.

10. Professor Pallas's contributions to the Memoirs of the Imperial Academy of St Petersburg are also very numerous, and on miscellaneous subjects. In the *Novi Commentarii* we find an account of the Tubularia Fungosa, vol. xii., observed near Wolodimer; Lepus pusillus, and Fossil Bones of Siberia, vol. xiii.; Quadrupeds and Birds observed in 1769, vol. xiv. 1; Remains of Exotic Animals in Northern Asia, vol. xviii., especially the skulls of the rhinoceros and the buffalo; Tetrao arenaria, Equus hemionus, and Lacerta apoda, vol. xix.; the last also in Geneesk. Jaerboek, ii. In the *Acta* for 1777, ii., An Account of the Teeth of an Unknown Animal, like those which have been found in Canada; Observations, from Camper's Letters, on a Myrmecophaga and a Didelphis, and Equus asinus in the wild state. In the volume for 1779, ii., a Description of Plants peculiar to Siberia; Capra Caucasica, also in Lichtenberg's *Magazin*, ii. For 1780, part i. Galeopithecus vitans; part ii. On the Variations of Animals, and Didelphis brachyura. For 1781, part i., Felis manul, a new Asiatic species of Felis; ii., On some Species of Sorex. In the volume for 1783, New Species of Fishes; and 1784, On some new Marine Productions.

11. The Observations sur la Formation des Montagnes, et les Changemens arrivés au Globe, particulièrement à l'égard de l'Empire Russe, published separately, 4. Petersb. 1777, were also inserted in the *Acta* of the Academy for 1777, having been read at a public sitting before the king of Sweden. A translation of this discourse is inserted in Tooke's Russian Empire, and some remarks on it are found in the *Journal de Physique*, vol. xiii.

12. The most considerable of the separate publications of Pallas was the account of his travels, entitled Reise durch verschiedene provinzen des Russischen Reichs, 3 vols. 4. Petersburg, 1771–3–6; French, 8vo, 8. Par. 1803; English, 2 vols. 4. London, 1812; a work of the highest authority in geography and natural history. 13. It was in the course of these travels that Pallas observed in Siberia an insulated mass of native iron, which he described in a paper addressed to the Royal Society of London, and printed in the Philosophical Transactions for 1776, p. 523; a substance which has become the subject of many discussions, from its resemblance to some of the specimens of well-ascertained aërolites; the author mentions also the remains of an unmineralized rhinoceros, which had been found in the same country.

14. In the *Beschäftigungen Naturforschenden Freunden*, published at Berlin about 1777, we find a letter on the Acipenser ruthenus, or sturgeon, vol. ii. p. 532; and An Account of a Monstrous Horse, vol. iii. p. 226. 15. Some Mineralogical Observations, addressed to Born, are published in the *Böhmische Abhandlungen*, vol. iii. p. 191. 16. In the Swedish *Handlingar* for 1778, we have the Alauda Mongolica, and the Sturnus Daauricus; the Anas glocitans, in 1779.

17. Novæ species Glirium, 4. Erlang. 1778. 18. Icones, Insectorum, præsertim Rossiæ Sibiriæque, 4. Erlang. 1781. 19. Enumeratio Plantarum Procopii a Demidoff, 8. Petersb. 1781.

20. Another channel in which a number of Pallas's most valuable essays appeared, is the work entitled *Neue Nordische Beyträge*, which he published at St Petersburg and Leipzig in 1781 and the following years. The most remarkable of the subjects of these are, A great Exotic Animal found in Kasan in the year 1776; on the Migration of the Water-Rat on the Volga, and Observations on Tæniæ, vol. i.; further Remarks on Tæniæ; on American Monkeys bred at St Petersburg; on the Ardea helias; on the Culex lanio, sometimes fatal to Cattle; on the Phalangium, or Scorpion Spider; and on Copper Island, in the Sea of Kamtschatka, vol. ii.: on Two Birds; and on the Labrador Stone, vol. iii.: on a Cross of the Black Wolf with the Dog; on a Mine; on the Oriental Turquois; and Mineralogical Novelties from Siberia, vol. v. Pallavicini.

21. In the *Physische Arbeiten* of Vienna, we have a geological Essay on the Orography of Siberia, vol. i. 1.

22. Flora Rossica, f. vol. i. Petersb. 1784; ii. 1788, published at the expense of the empress.

23. Tableau Physique et Topographique de la Tauride, 4. Petersb. 1795; German, in *N. N. Beyträge*, vii.: a work derived chiefly from the observations made by the author in his travels of 1792.

24. A Monography of the Astragali is mentioned by some of his biographers.

25. He edited also Guldenstädt's *Reisen durch Russland und in den Caucasischen gebirgen*, ii. v. 4. Petersb. 1787–1791. 26. He also compiled and arranged the two first and most valuable of the four volumes of the Vocabularia Comparativa, 4. Petersb. 1787, in which he attempted to make some improvements in the Russian orthography.

(Coxe's *Travels*; Clarke's *Travels*; Tooke's *Russian Empire*; Halleri *Bibliotheca Anatomica*; Aikin's *General Biography*, vol. x. 4to, Lond. 1815; Chalmers's *Biographical Dictionary*, vol. xxiii. 8vo, Lond. 1815; Dryander, *Bibliotheca Banskiana*.) (L. L.)

PALLAVICINI FERRANTE, a noted Italian writer, descended from a noble family in Piacenza, was born about the close of the sixteenth century. He soon gave proofs of an extraordinary genius, and improved rapidly in classical erudition. He was afterwards sent to complete his education in the monastery of Augustinian friars at Milan, where he took the habit, lived much esteemed for piety and learning, and raised great expectations of future fame; but being somewhat amorously inclined, he engaged in an intrigue with a young woman of Venice, whose charms proved irresistible; and in order to enjoy them without restraint, he obtained leave from his general to make the tour of France. Accordingly he pretended to set out for that country; but it was only a blind to cover his real design. He never left Venice, where he lived privately, enchanted with the attractions of his Venus; and having too ready a talent for invention, he imposed upon his friends, by often sending them, in letters, feigned accounts of his travels through France, and also informing them of several things respecting that court, which he learned from the advices of many considerable persons with whom he corresponded.

His finances were in the mean time greatly reduced; and in this exigency he naturally had recourse to his wits for supplies. He wrote for the booksellers, and composed several pieces, more for the sake of gain than out of any fondness for authorship. Amongst other things, he wrote a collection of letters, mostly satirical, which he called The Courier Robbed of his Mail. The work appeared at first in such a cast as could not give great offence, except to the Spaniards, against whom he had some grudge, and the piece was accordingly licensed by the inquisitors; but when it fell into the hands of the secre-

Pallavicini.

tary of the republic of Venice, who was at that time licenser of books, he refused his *imprimatur*, though great interest was employed for that purpose; neither would he return the manuscript. This enraged Pallavicini so much, that had not his friends restrained him, he would have pursued the affair to his ruin.

At length he found an opportunity of travelling into Germany with the Duke of Amalfi, as his grace's chaplain. But this journey had no good effect either on his wit or his morals. On the contrary, finding himself, from the manners of the Germans, more at liberty, he indulged his genius and passions with greater freedom; and after a residence of more than a year in that country with the duke, he returned to Venice. He was now resolved to have his full measure of revenge against the secretary of the republic for keeping back his manuscript, and also to attack the family of Barberini, Urban VIII. and his nephews, because they had also endeavoured to get all his manuscripts prohibited. In this rancorous spirit he cast his Courier into a new model, and enlarged it with many letters and discourses. Thus new modelled, he offered it to a bookseller, who undertook to get it printed; but our author was betrayed by a pretended friend, who acted the part of a spy, and informed the Archbishop of Vitelli, then the pope's nuncio at Venice, just as the work was finished at the press; and upon the complaint of the nuncio, Pallavicini was imprisoned. In this miserable condition he found a friend in one of his mistresses, who, seeing him abandoned by most of his patrons, not only supported him, but conveyed letters to him, by which she gave him such information as enabled him to make a proper defence, and to recover his liberty.

But a war having in the mean time broken out between the Barberini and the Duke of Parma, Pallavicini, in order to revenge himself upon the supposed instruments of his imprisonment, wrote a piece entitled *Buccinata, ovvero Butarella, per le api Barberini*, and dedicated it, in terms of the profoundest contempt, to the nuncio Vitelli. The nuncio, finding that little notice was taken of his complaints on the occasion, procured by bribery one Charles Morfu, a Frenchman, who pretended to pass for a gentleman, to ensnare Pallavicini; and with this view the traitor used his utmost endeavours to insinuate himself into the friendship of Pallavicini, and at length exhorted him to accompany him to France. He declared that his fortune would be made by the extraordinary encouragement which was given to men of letters by Cardinal Richelieu; and the better to favour the deceit, he produced feigned letters from the cardinal, inviting our author to France, and expressing a desire he had to establish in Paris an academy for the Italian tongue, under the direction of Pallavicini. The snare took; and Pallavicini, fascinated by the prospect of gain, suffered himself to be led like an ox to the slaughter. He left Venice much against the advice of his friends, and went first to Bergamo, where he spent a few days with some of his relations, by way of entertaining Morfu. They then set off for Geneva, to the great satisfaction of Pallavicini, who proposed to get some of his works printed there, which he had not been able to do in Italy. Morfu, however, instead of conducting him to Paris, took the road to Avignon, where, crossing the bridge of Soraces, in the county of Venaissin, they were seized by a gang of *sbirri*, on pretence of carrying contraband goods, and confined. Morfu was quickly discharged, and very liberally rewarded; but Pallavicini, being carried to Avignon, was imprisoned; and notwithstanding he made a very skilful defence, it was all in vain. The sentence had already been brought from Rome, and he was to undergo trial, merely for form's sake. Being now put into a dark dungeon, he made an abortive effort to escape. He managed matters so well with his keeper as to procure wax-candles to be allowed him, under pretence of amusing himself with reading, and when he had got a number of these, he one night set fire to the prison door, in order to get off by that means; but the stratagem did not succeed, and he was of course subjected to closer confinement, and treated with greater inhumanity than before. After a year's suffering, he was brought to trial, in which he made an excellent defence, and flattered himself with hopes of relief. He had even begun a whimsical piece on the subject of melancholy; but, contrary to his expectations, he was sentenced to die, and lost his head on a scaffold, in the flower of his age.

Palleeangan Isle. || Pallium.

Pallavicini was of so heedless and profuse a disposition, that had he possessed an immense estate he would have spent it all. On the other hand, no one could be more sincere and faithful in his friendships, nor was there ever a greater victim to treachery; yet, when released from prison in Venice, being told that a wretch had betrayed him, he could not be prevailed upon to believe it, saying, "How can this be, since he declared himself my friend, and I made him privy to all my concerns?" Whilst he wore a religious habit, he used to study or write two or three hours in bed every morning. The rest of the day he spent either in the company of idle persons, or else with the ladies; but after he had wholly left the monastic life, upon pretence of securing himself from the snares of his enemies, he lived in a very irregular manner. He was possessed of a fine genius, had a great facility in writing, and, till he was corrupted by the commerce of lewd women, wrote pieces worthy of immortality.

PALLEEANGAN Isle, a small, low, woody island, one of the Sooloo archipelago, having a salt-water lake in the centre.

PALLET, amongst painters, a little oval table, or piece of wood or ivory, very thin and smooth, upon which the painters place the several colours they have occasion for, to be ready for the pencil. The middle serves to mix the colours on, and to make the tints required in the work. It has no handle, but, instead thereof, a hole at one end to put the thumb through, and thus hold it.

Pallet, amongst potters, crucible makers, and others, a wooden instrument, indeed almost the only one they use, for forming, beating, and rounding their works. They have several kinds of pallets. The largest are oval, with a handle; but others are round, or hollowed triangularly; and others, again, are like large knives, serving to cut off whatever is superfluous on the moulds of their work.

Pallet, in gilding, an instrument made of a squirrel's tail, to take up the gold leaves from the pillow, and to apply and extend them on the matter to be gilt.

Pallet, in *Heraldry*, is nothing but a small pale. Upon one shield there are sometimes several pallets.

PALLIATÆ, a name which the Romans gave to such plays as laid the plot in Greece, and required the performers to appear in Grecian habits. It is used in contradistinction to *togatæ*, in which the scene was laid at Rome, and in which the dresses were Roman. The word *palliatæ* is derived from *pallium*, which was a part of dress peculiar to the Greeks; whereas the *toga* belonged exclusively to the Romans.

PALLISER, Cape, on the south coast of Eaheinomauwe, is the most northern island of New Zealand, and the north-east point of Cook's Strait. Long. 183. 58. W. Lat. 41. 34. S.

Palliser's *Islands*, a cluster of small islands in the South Pacific Ocean; the largest about fifteen miles long and nine broad, being connected by a reef of coral rocks, difficult of access. Long. 146. 30. W. Lat. 13. 38. S.

PALLIUM, a word often mentioned in our old historians. Durandus tells us that it is a garment made of white wool, after the following manner, viz. The nuns of

Pallium ‖ Palma.

St Agnes offer every year, on the feast day of their saint, two white lambs on the altar of their church, during the time of singing the *Agnus Dei*, in a solemn mass; and these lambs are afterwards taken by two of the canons of the Lateran church, and by them given to the pope's subdeacons, who send them to pasture till shearing time, when they are shorn, and the pall is made of their wool mixed with other white wool. The pall being thus made, is carried to the Lateran church, and there placed on the high altar, by the deacons of that church; and after the usual watching, it is carried away in the night, and delivered to the subdeacons, who lay it up safe. The *pallium* signifies the plenitude of ecclesiastical power; and therefore it was the prerogative of the popes, as the successors of St Peter, to invest other prelates with it. At first this was done nowhere but at Rome; though afterwards the ceremony was performed at other places.

PALLIUM, in *Antiquity*, was an upper garment or mantle worn by the Greeks, as the *toga* was by the Romans. These habits were so peculiar to the two nations respectively, that *Palliatus* was used to signify a Greek, and *Togatus* a Roman.

PALM has amongst almost all nations been regarded as an emblem of victory, and assigned as the reward of it. The reason why this tree was adopted and made use of to represent victory, is said to be, because it is so elastic, that if pressed by the greatest weight, it will rise superior to the pressure, and be able to restore itself to its former state, appearing almost invincible.

PALM *Islands*, a chain of islands near the north-eastern coast of New Holland, extending almost thirty miles in length, at the entrance of Halifax Bay. Long. 213. 25. W. Lat. 18. 53. S.

PALM-SUNDAY, in the Christian church, the Sunday next before Easter, being so called in memory of our Saviour's triumphal entry into Jerusalem, when the multitude who attended him strewed palm branches on his way.

PALMA, one of the Canary Islands, situated off the coast of Western Africa. The soil of this island is more elevated than Teneriffe, being hilly, and full of caverns. It is generally fertile and populous only on its coasts, where are cultivated vegetables, good wine, a great deal of sugar used principally in preserving fruit, in which the island abounds, and a great quantity of almonds. In its southern part Palma is very barren, being strewed with the products of volcanic action. The centre is often covered with snow, and contains extensive pine forests, as well as good timber for ship-building. The region of clouds only is thickly wooded, which gives the island the appearance of a forest when seen from a distance. Tradition says that the Spaniards gave it the name which it bears, from its having a resemblance to a palm-tree when seen from the ocean. The produce in corn is not sufficient for the consumption of the inhabitants, so that in years of scarcity they live on the roots of fern, as at Gomera, another of the group. According to Clavijo, there are neither fallow-deer, partridges, nor hares on this island; but rabbits are very numerous, and destructive to the young trees. One of the principal branches of trade is the fishing, which is prosecuted on the coast of Africa in small vessels. The fish being salted, serves, with potatoes, for the food of the common people throughout the islands. Palma is one of the three royal islands, and had a liberty to trade with America, which was not taken advantage of; its commercial intercourse being almost entirely with Teneriffe, and Spain, the mother country. Volcanic eruptions have repeatedly spread ruin and consternation throughout Palma, and its liability to these terrible visitations it shares with Teneriffe and Lanzerota. Santa Cruz de las Palmas, the capital, has a good port. Palma is about twenty-five miles in length by fifteen miles in breadth, and in 1835 contained 33,089 inhabitants.

Palma ‖ Palmyra.

PALMA, the capital of Majorca, one of the Balearic Islands, belonging to Spain, in the Mediterranean Sea. It has a most excellent harbour, formed by Cape Calafiguera and Cape Blanco, and is very respectably fortified. The city contains 30,000 inhabitants, subsisting on the produce of the fertile fields that surround them, on that of the fisheries, and by means of considerable foreign commerce in silk, thread, oranges, lemons, dates, almonds, and flax. It is the see of a bishop, and has a large cathedral, an academy for drawing, a literary seminary, and, which is the best of the buildings, a large mercantile exchange. The cathedral, by accurate observation, is in east longitude 3. 9. 45. from London, and in north latitude 39. 34. 4. It has a mole 4380 feet long. It contains 3000 large houses, and 29,529 inhabitants.

PALMA, a town of the island of Sicily, in the intendancy of Calatinata, and district of Mazzara. It is situated on a fine plain, near gentle hills, on the sea-shore, eighty-six miles from Palermo. It is a healthy place, with 8400 inhabitants, who deal in wine, corn, honey, and other productions of their fertile soil.

PALMA, a town of Italy, in the province Terra di Lavoro, of the kingdom of Naples. It stands on a fertile plain, and contains 6300 inhabitants.

PALMAS, LAS, capital of the Great Canary, one of the group of the Canaries, situated off the coast of Western Africa. It is a large handsome town, and in 1835 contained 18,000 inhabitants. There are a cathedral, an hospital, and a college, with convents for monks and nuns of all orders. The city is well supplied with water, having fountains in all the principal streets and squares; and there is a public market, which is always abundantly stocked with provisions.

PALMERSTON ISLAND, in the South Pacific Ocean, discovered by Captain Cook, and afterwards visited by Captain Wilson in the missionary ship Duff. It has the appearance of one island, but consists really of eight or nine. There are no inhabitants on the island, but numerous rats, supposed to have been drifted here on some hollow tree or root. Long. 163. 10. W. Lat. 18. 4. S.

PALMI, a city of Italy, in the province of Calabria Ulteriore I., of the kingdom of Naples. It stands on the sea, in a district highly productive of silk, wine, and oil. It contains 6100 inhabitants, many of them employed in woollen and silk manufactures. It was almost wholly destroyed by the earthquake of 1783, but has since been rebuilt.

PALMIRAS, a celebrated point of land at the head of the Bay of Bengal, which all vessels bound for Calcutta endeavour to make, and on which the East India Company have erected a lighthouse. Long. 87. 5. E. Lat. 20. 44. N.

PALMISTRY, a kind of divination, or rather a deceitful art practised by gipsies, who pretend to foretell events by looking upon the lines and marks of the hand.

PALMUS, a long measure used both by the Greeks and the Romans. The Grecian *palmus* was of two sorts; the greater, which contained nine finger-breadths, and the less, which contained four. The Roman *palmus* was also of two sorts; the greater, which contained twelve finger-breadths, or eight inches and a half English; and the less, which contained four finger-breadths, or nearly three inches English. The great *palmus* was taken from the length of the hand or span, the less from the breadth of it.

PALMYRA, or TADMOR, a noble city of ancient Syria, now in ruins. The origin of this name is uncertain, neither is it well known by whom the city was built; for though, from the identity of the names, it is thought by many to have been the *Tadmor in the wilderness* built by Solomon,[1] yet this point is much controverted by many learned men.

[1] See 1 Kings, ix. 18; and 2 Chron. viii. 4; and Josephus, *Antiq. Jud.* lib. i.

Palmyra. For the world have long and justly been astonished to find in the desert of Syria, at a distance from the sea, with a very precarious and scanty supply of water, and without a particular connection with any great monarchy, ruins of a city more extensive and splendid than Rome itself, the depositary of all the arts which Greece in its most flourishing periods could display. The problem is an intricate one; yet when we divest it of many of its difficulties, we shall perhaps reduce this stupendous prodigy to no very uncommon magnitude. The coast of Syria was in early times rich and populous; and, either from the convenience of procuring water, or from the vicinity of India and Egypt, the population, instead of increasing on the mountains, extended to Judea, and thence through its plains only to the internal parts. Traces of this numerous people, and the ruins of their habitations, still remain; but as their edifices were not uncommonly splendid, or as the causes of their destruction were powerful, they have not attracted much attention. Yet the ruins of more than thirty towns are discoverable to the south-east of the Dead Sea, and thence towards Tadmor or Palmyra; we know the cause of the destruction of these towns, and we know that it did not reach Palmyra. This splendid city was not, therefore, insulated in a mass of sand; it was probably a link of a continued chain of population, or perhaps its termination. The situations of towns in the sandy desert must necessarily be determined by local advantages. Tadmor is situated on a spot where two hills converge, and beyond the point where they approach. These hills afforded water; and the aqueducts through which it was brought from them were discovered and described by Mr Wood. Though the other towns now in ruins exhibit some remains of luxury and opulence, yet in these respects they are much inferior to Palmyra; and this deserves to be here explained. Palmyra was undoubtedly very ancient. "The two springs of fresh water it possesses," says Volney, "were, above all, a powerful inducement in a desert everywhere else so parched and barren. These, doubtless, were the two principal motives which drew the attention of Solomon, and induced that commercial prince to carry his arms so remote from the limits of Judea."[1] "He built strong walls there," says the historian Josephus, "to secure himself in the possession, and named it *Tadmor*, which signifies the Place of Palm-trees." Hence it has been inferred that Solomon was its first founder; but from this passage we should be rather led to conclude that it was already a place of known importance. The palm-trees he found there are not the trees of uninhabited countries. Prior to the days of Moses, the journeys of Abraham and Jacob from Mesopotamia into Syria sufficiently prove that a communication existed between these countries, which must soon have rendered Palmyra flourishing. The cinnamon and pearls mentioned in the time of the Hebrew legislator demonstrate a trade with India and the Persian Gulf, which must have been carried on by the Euphrates and Palmyra. At this distance of time, when the greater part of the monuments of those early ages have perished, we are liable to form very false opinions concerning the state of these countries in remote times, and are the more easily deceived, sometimes admitting as historical facts antecedent events of an entirely different character. Observing, however, that men in all ages are united by the same interests and the same desires, we cannot help concluding, that a commercial intercourse must early have taken place between one nation and another, and that this intercourse must have been nearly the same with that of more modern times. Without, therefore, going higher than the reign of Solomon, the invasion of Tadmor by that prince is sufficient alone to throw light upon the history of this city. The king of Jerusalem would never have directed his attention to so distant and detached a spot, without some powerful motive of interest; and this interest could be no other than that of an extensive commerce, of which this place was already the emporium. This commerce extended itself to India; and the Persian Gulf was the principal point of union. Palmyra.

From the nature of the commodities, from the requisite assistance of the Tyrians, and other forcible arguments, Volney shows that the Persian Gulf was the centre of the most ancient commerce of the eastern world; and that it was with a view of obtaining a shorter route, by means of the Euphrates, that Solomon turned his attention to Tadmor, distant only three days' journey. "We may even reasonably conjecture," says Volney, "when we reflect on the revolutions of the following ages, that this commerce became a principal cause of those various wars in Lower Asia, for which the barren chronicles of those early times assign no motives. If, after the reign of Solomon, the Assyrians of Nineveh turned their ambitious views towards Chaldea and the lower part of the Euphrates, it was with the intention to approach that great source of opulence, the Persian Gulf. If Babylon, from being the vassal of Nineveh, in a short time became her rival, and the seat of a new empire, it was because her situation rendered her the emporium of this lucrative trade; in short, if the kings of this great city waged perpetual wars with Jerusalem and Tyre, their object was not only to despoil these cities of their riches, but to prevent their invading their trade by the way of the Red Sea. An historian who has informed us that Nebuchadonosor, before he laid siege to Jerusalem, took possession of Tadmor, clearly indicates that the latter city acted in concert with the two neighbouring capitals. Their gradual decline became, under the Persian empire, and the successors of Alexander, the efficient cause of the sudden greatness of Palmyra in the time of the Parthians and the Romans; she then enjoyed a long peace for many centuries, which allowed her inhabitants to erect those monuments of opulence whose ruins we still admire." If the former observations showed the connection of this remote spot with a more populous country, these remarks explain the cause of the renovation and magnificence of this city. Cairo, in another, probably a subordinate route, never attained the splendour of Palmyra; but the genius of the Egyptians, and perhaps the laws of Egypt, prevented it.

There is, however, no authentic history of Palmyra till after the capture of the Emperor Valerian by the Persians. It is first mentioned by the Roman historians as a place which Marcus Antonius attempted to plunder, upon pretence that it had not observed a just neutrality between the Romans and Parthians. Pliny takes notice of it as being situated in a rich soil, amongst pleasant streams, and totally separated from the rest of the world by a vast sandy desert, which had preserved its independence between Parthia and Rome. There is still a considerable spot of good soil next the town and on the hills; and even in the wilderness there were palm and fig trees, some of which remained till the latter end of the seventeenth century, though not one is now to be found.

After the captivity of Valerian, it became an opulent city, to which its situation in the vicinity of the Roman and Parthian empires greatly contributed; since the caravans, in going to or returning from the East, frequented the place, and thus rendered it a considerable seat of merchandise. It enjoyed independence till the time of Trajan, who, having made himself master of almost all the Parthian empire, likewise reduced Palmyra, which was afterwards accounted part of the Roman dominions. But when the defeat and captivity of Valerian had so much

[1] Travels through Syria and Egypt.

Palmyra. weakened the empire that the Persians seemed to be in a fair way of becoming masters of all the eastern provinces, the Palmyrans began to entertain thoughts of recovering their liberty. Odenathus, prince of Palmyra, sent a respectful letter to Sapor on his return, accompanied with considerable presents; but by that haughty conqueror his letter and embassy were treated with contempt. The presents were thrown into the Euphrates; and to the letter Sapor replied, that the insolence of the prince in presuming to write to his lord was inexcusable; but if he could atone for it in any way, it would be by presenting himself before the throne, bound hand and foot, in token of consciousness of his crime, and the punishment he deserved. This injurious treatment so provoked Odenathus, that he swore either to humble the pride of the haughty conqueror, or to die in the attempt. Accordingly, having assembled all the forces he could muster, he fell upon the Persians, destroyed a number of them, and took a great part of their baggage, with some of the king's concubines. Of the war of Odenathus with the Persians, however, very little is known, except that, though the latter were often vanquished, and the independence of Palmyra established for the present, yet Valerian was never released from his captivity, though Odenathus earnestly wished to have the honour of rescuing him from his enemies.

Odenathus enjoyed his sovereignty but a very short time, being murdered by his nephew, who was soon afterwards put to death by Zenobia, the wife of Odenathus. This lady is said to have been possessed of extraordinary endowments both of body and mind; having, according to Mr Gibbon, been almost the only Asiatic woman who is recorded to have overcome the obstacles arising from the confined situation of the fair sex in that part of the world. Immediately on taking vengeance for the murder of her husband, she assumed the government, and soon strengthened herself so much, that she resolved to submit neither to the Roman nor the Persian rule. The neighbouring states of Arabia, Armenia, and Persia, dreaded her enmity, and solicited her alliance. To the dominions of Odenathus, which extended from the Euphrates to the frontiers of Bithynia, his widow added the inheritance of her ancestors, the populous and fertile kingdom of Egypt. The Emperor Claudius acknowledged her merit, and was content, that whilst he pursued the Gothic war, she should assert the dignity of the empire in the East. The conduct of Zenobia, however, was attended with some ambiguity; nor is it unlikely that she had conceived the design of erecting an independent and hostile monarchy. She blended with the popular manners of Roman princes the stately pomp of the courts of Asia, and exacted from her subjects the same adoration that was paid to the successors of Cyrus. She bestowed on her three sons a Latin education, and often showed them to the troops, adorned with the imperial purple. For herself she reserved the diadem, with the splendid but doubtful title of Queen of the East.

When Aurelian passed over into Asia against this singular adversary, his presence restored to obedience the province of Bithynia, already shaken by the arms and intrigues of Zenobia. Advancing at the head of his legions, he accepted the submission of Ancyra, and was admitted into Tyana, after an obstinate siege, by the help of a perfidious citizen. The generous although fierce temper of Aurelian abandoned the traitor to the rage of the soldiers; but a superstitious reverence induced him to treat with lenity the countrymen of Apollonius the philosopher. Antioch was deserted on his approach, till the emperor, by his salutary edicts, recalled the fugitives, and granted a general pardon to all who, from necessity rather than choice, had been engaged in the service of the queen of Palmyra. The unexpected mildness of such a conduct reconciled the minds of the Syrians, and, as far as the gates of Emesa, the wishes of the people seconded the terror of his arms. Palmyra.

Zenobia would have ill deserved her reputation had she indolently permitted the emperor of the west to approach within a hundred miles of her capital. The fate of the East was decided in two great battles, so similar in almost every circumstance, that we can scarcely distinguish them from each other, except by observing that the first was fought near Antioch, and the second near Emesa. In both, the queen of Palmyra animated the armies by her presence, and devolved the execution of her orders on Zabdas, who had already signalized his military talents by the conquest of Egypt. The numerous forces of Zenobia consisted for the most part of light archers, and of heavy cavalry clothed in complete steel. The Moorish and Illyrian horse of Aurelian were unable to sustain the ponderous charge of their antagonists. They fled in real or affected disorder, engaged the Palmyrans in a laborious pursuit, harassed them by a desultory combat, and at length discomfited this impenetrable but unwieldy body of cavalry. The light infantry, in the mean time, when they had exhausted their quivers, remaining without protection against a closer onset, exposed their naked sides to the swords of the legions. Aurelian had chosen the veteran troops, who were usually stationed on the Upper Danube, and whose valour had been severely tried in the Allemannic war. After the discomfiture of Emesa, Zenobia found it impossible to collect a third army. As far as the frontier of Egypt, the nations subject to her empire had joined the standard of the conqueror, who now detached Probus, one of the bravest of his generals, to take possession of the Egyptian provinces. Palmyra was the last resource of the widow of Odenathus. She retired within the walls of her capital, made every preparation for a vigorous resistance, and declared, with the intrepidity of a heroine, that the last moment of her reign and of her life should be the same.

In his march over the sandy desert between Emesa and Palmyra, the Emperor Aurelian was perpetually harassed by the Arabs; nor could he always defend his army, and especially his baggage, from those flying troops of active and daring robbers, who watched the moment of surprise, and derided the slow pursuit of the legions. The siege of Palmyra was an object far more difficult and important; and the emperor, who with incessant vigour pressed the attacks in person, was himself wounded with a dart. "The Roman people," says Aurelian, in an original letter, "speak with contempt of the war which I am waging against a woman. They are ignorant both of the character and of the power of Zenobia. It is impossible to enumerate her warlike preparations, of stones, of arrows, and of every species of missile weapons. Every part of the walls is provided with two or three balistæ, and artificial fires are thrown from her military engines. The fear of punishment has armed her with a desperate courage. Yet I trust still in the protecting deities of Rome, who have hitherto been favourable to all my undertakings." Doubtful, however, of the protection of the gods, and of the event of the siege, Aurelian judged it more prudent to offer terms of an advantageous capitulation; to the queen a splendid retreat, to the citizens their ancient privileges. His proposals were obstinately rejected, and the refusal was accompanied with insult.

The firmness of Zenobia was supported by the hope that in a very short time famine would compel the Roman army to repass the desert; and by the reasonable expectation that the kings of the East, and particularly the Persian monarch, would arm in defence of their most natural ally. But fortune, and the perseverance of Aurelian, overcame every obstacle. The death of Sapor, which happen-

Palmyra. ed about this time, distracted the councils of Persia; and the inconsiderable succours which attempted to relieve Palmyra were easily intercepted either by the arms or the liberality of the emperor. From every part of Syria a regular succession of convoys safely arrived in the camp, which was increased by the return of Probus with his victorious troops from the conquest of Egypt. It was then that Zenobia resolved to fly. She mounted the fleetest of her dromedaries; and had already reached the banks of the Euphrates, about sixty miles from Palmyra, when she was overtaken by Aurelian's light horse, seized, and brought back a captive to the feet of the emperor. Her capital soon afterwards surrendered, and was treated with unexpected lenity. The arms, horses, and camels, with an immense treasure of gold, silver, silk, and precious stones, were all delivered to the conqueror; who, leaving only a garrison of six hundred archers, returned to Emesa, and employed some time in the distribution of rewards and punishments at the end of a war which restored to Rome those provinces which had renounced their allegiance since the captivity of Valerian.

When the Syrian queen was brought into the presence of Aurelian, he sternly asked her, how she had presumed to rise in arms against the emperors of Rome. The answer of Zenobia displayed a prudent mixture of respect and firmness: "Because I disdained to consider as Roman emperors an Aureolus or a Gallienus. You alone I acknowledge as my conqueror and my sovereign." But as female fortitude is commonly artificial, so it is seldom steady or consistent. The courage of Zenobia deserted her in the hour of trial. She trembled at the angry clamours of the soldiers, who called aloud for her immediate execution; forgot the generous despair of Cleopatra, which she had proposed as her model; and ignominiously purchased life by the sacrifice of her fame and her friends. It was to their counsels, which governed the weakness of her sex, that she imputed the guilt of her obstinate resistance; it was upon their heads that she directed the vengeance of the cruel Aurelian. The fame of Longinus, who was included amongst the numerous and perhaps innocent victims of her terror, will survive that of the queen who betrayed or the tyrant who condemned him. Genius and learning were incapable of moving a fierce unlettered soldier; but they had served to elevate and harmonise the soul of Longinus. Without uttering a complaint, he calmly followed the executioner, pitying his unhappy mistress, and bestowing comfort on his afflicted friends.

Returning from the conquest of the East, Aurelian had crossed the straits which divided Europe from Asia, when he was provoked by the intelligence that the Palmyrans had massacred the governor and garrison which he had left amongst them, and again erected the standard of revolt. Without a moment's deliberation, he once more turned his face towards Syria. Antioch was alarmed by his rapid approach, and the helpless city of Palmyra felt the irresistible weight of his resentment. We have a letter of Aurelian himself, in which he acknowledges that old men, women, children, and peasants, had been involved in that dreadful execution, which should have been confined to armed rebellion; and although his principal concern seems directed to the re-establishment of a temple of the Sun, he discovers some pity for the remnant of the Palmyrans, to whom he grants the permission of rebuilding and inhabiting their city. But it is easier to destroy than to restore. The seat of commerce, of arts, and of Zenobia, gradually sunk into an obscure town, a trifling fortress, and at length a miserable village.

Little is known concerning the fortunes of Palmyra since the time of Mahommed, except that it was considered as a place of strength, and that in the twelfth century there were two thousand Jews in it. With respect to the ruins, they appear to be of two different and distinct periods: the oldest are so far decayed as not to admit of mensuration, and look as if they had been reduced to that state by the hand of time; the others appear to have been broken into fragments by violence. Of the inscriptions none is earlier than the birth of Christ, and none is later than the destruction of the city by Aurelian, excepting one, which mentions Dioclesian. Palmyra.

Mr Wood is of opinion, that the face of the country which surrounds Palmyra was always the same; but though Palmyra was ever believed to be situated in a wilderness, it does not follow that the wilderness was always of the same extent. It is perhaps more probable, that when Palmyra was first settled, the rich soil mentioned by Pliny extended much farther; for whatever were the reasons for making a settlement there, Palmyra can scarcely be supposed to have invited a greater number of people than it could feed. The palms and fig-trees that were formerly found upon the hills, and in the borders of the desert, that are now totally barren, confirm this opinion. Mr Wood observes, that whilst he was there a whirlwind happened, which raised such quantities of sand as quite darkened the sky: this sand, therefore, might by degrees encroach upon the fertile environs of Palmyra, and reduce the number of inhabitants as it reduced their sustenance, till the few wretched families only were left, who found it difficult to furnish food for Mr Wood and his company, although they did not continue longer than a fortnight among them. It will also appear from history, that what is supposed to have happened here has happened at other places, where such an event was much less probable. On the sea-coast in the neighbourhood of St Pol de Léon, in Lower Bretagne, there is a considerable tract of land, which before the year 1666 was inhabited, but which was rendered uninhabitable by a sand, which, encroaching every year, covered it to the depth of above twenty feet. In the year 1718 it had advanced more than six leagues, and within one league of St Pol; so that it was then thought probable that the town would of necessity be abandoned. This sand is raised by the east or north-east wind, which drives it in clouds with great swiftness, and in a prodigious quantity.[1] It was also attested by the captain of a ship, and all on board, that in the year 1719 there fell in the Atlantic Ocean, at fifteen degrees of north latitude, and at the distance of more than eight leagues from any land, a shower of sand, some of which they produced, and deposited in the academy at Paris.[2]

The company with whom Mr Wood travelled arrived at length at the end of the plain, where a ridge of barren hills, by which it was divided on the right and left, seemed to meet; between them there was a vale, through which an aqueduct formerly conveyed water to Palmyra. On each side of this vale they remarked several sepulchres of the ancient Palmyrans, which they had scarcely passed, when the hills opening on a sudden, they discovered such piles of ruins as they had never seen. They were all of white marble; and beyond them, towards the Euphrates, was a wide level, stretching farther than the eye could reach, totally desolate, without variety, and without bounds. After having gazed some time upon this prospect, which rather exceeded than fell short of their expectations, they were conducted to one of the huts of the Arabs, of which there are about thirty in the court of the great temple. The inhabitants of both sexes were well shaped, and the women, though very swarthy, had good features. They were veiled, but did not so scrupulously conceal their faces

[1] Memoirs of the French Academy for 1718.

[2] History of the Academy, 1772.

Palmyra.

as the eastern women generally do. They stain the ends of their fingers red, their lips blue, and their eyebrows and eyelashes black. They had large rings of gold or brass in their ears and nostrils, and appeared to be healthy and robust. The walls of the city are flanked by square towers, into which some ancient funeral monuments have been converted; but the walls are in most places level with the ground, and sometimes not to be traced. It is, however, probable, by their general direction, that they included the great temple, and were three miles in circumference. The Arabs showed a tract which was near ten miles in circumference, the soil of which was raised a little above the level of the desert: they said that this was the extent of the old city; and that by digging in any part of it, ruins were discovered.

These ruins consist of temples, palaces, and porticos of Grecian architecture, and lie scattered over an extent of several miles. They were accidentally discovered by some English travellers from Aleppo, somewhat more than a century ago. By far the most remarkable of them is the Temple of the Sun, of which the ruins are spread over a square of two hundred and twenty yards. It was encompassed with a stately wall, built of large square stones, and adorned with pilasters within and without, to the number of sixty-two on a side. Within the court are the remains of two rows of very noble marble pillars thirty-seven feet in height, with their capitals of most exquisite workmanship. Of these only fifty-eight remain entire; but there must have been many more, for they appear to have gone round the whole court, and to have supported a double piazza. The walks on that side of the piazza which is opposite to the front of the castle seem to have been the most spacious and beautiful. At each end of this line are two niches for statues, with the pedestals, borders, supporters, and canopies, carved with the utmost propriety and elegance. The space within this enclosure, which is now filled with the dirty huts of the inhabitants, seems to have been an open court, in the middle of which stood the temple, encompassed with another row of pillars of a different order, and much taller, being fifty feet in height; but of these, sixteen only remain. The whole space contained within these pillars is fifty-nine yards in length, and near twenty-eight in breadth. The temple is no more than thirty-three yards in length, and thirteen or fourteen in breadth. It points north and south; and exactly at the middle of the building, on the west side, there is a most magnificent entry, on the remains of which are some vines and clusters of grapes carved in the most bold and masterly imitation of nature that can be conceived. Just over the door are discerned a pair of wings, which extend along its whole breadth; the body to which they belonged is totally destroyed; and it cannot now certainly be known whether it was that of an eagle or a cherub, several representations of both being visible on other fragments of the building. It is observed of the windows of this building, which were not large, that they were narrower at the top than below. The north end of the building is adorned with the most curious fret-work and bas-relief; and in the middle there is a dome or cupola about ten feet in diameter, which appears to have been either hewn out of the rock, or moulded to some composition which by time is grown equally hard. North of this place is an obelisk, consisting of seven large stones, besides its capital and the wreathed work about it. It is about fifty feet in height, and, just above the pedestal, is twelve feet in circumference. There was probably a statue upon it, which the Turks, in their zeal against idolatry, destroyed. At about the distance of a quarter of a mile from this pillar, to the east and west, there are two others, besides the fragment of a third; so that perhaps they were originally a continued row.

About a hundred paces from the middle obelisk, straight forward, there is a magnificent entry to a piazza, which is forty feet in breadth, and more than half a mile in length, enclosed with two rows of marble pillars twenty-six feet in height and eight or nine feet in compass. Of these there still remain one hundred and twenty-nine; and, by a moderate computation, there could not originally have been less than five hundred and sixty. The upper end of the piazza was shut in by a row of pillars, standing somewhat closer than those on each side. A little to the left are the ruins of a stately building, which appears to have been a banqueting-house. It is built of better marble, and is finished with yet greater elegance, than the piazza. The pillars which supported it were of one entire stone, which is so strong, that one of them which has fallen down has received no injury. It measures twenty-two feet in length, and in compass eight feet nine inches. In the west side of the piazza are several apertures for gates into the court of the palace. Each of these was adorned with four porphyry pillars, not standing in a line with those of the wall, but placed by couples in the front of the gate facing the palace, two upon each side. Two of these only remain entire, and but one standing in its place. They are thirty feet in length, and nine in circumference. On the eastern side of the piazza stands a great number of marble pillars, some of them perfect, but the greater part mutilated. In one place eleven are ranged together in a square. The space which they enclose is paved with broad flat stones, but there are no remains of a roof. At a little distance are the remains of a small temple, which is also without a roof, and has the walls very much defaced. Before the entry which looks to the south is a piazza, supported by six pillars, two upon each side of the door, and one at each end. The pedestals of those in front have been filled with inscriptions both in the Greek and Palmyran languages, which are become totally illegible. Amongst these ruins are many sepulchres; they are ranged upon each side of a hollow way, toward the north part of the city, and extend more than a mile. They are all square towers, four or five stories in height. But though they are alike in form, yet they differ greatly in magnitude and splendour. The outside is of common stone, but the floors and partitions of each story are marble. There is a walk across the whole building, just in the middle; and the space on each hand is subdivided into six partitions by thick walls. The space between the partitions is wide enough to receive the largest corpse; and in these niches there are six or seven piled upon one another.

Many inscriptions have been found at Palmyra which have occupied much of the attention of the learned; and if any thing certain could be derived from them, there is no doubt that they would tend very considerably to elucidate ancient history. See Barthélemy's *Reflections on the Palmyran Alphabet*, published at Paris in 1754. See also *Phil. Trans.* (No. 217 and 218); the first volume of the *Ancient Universal History*; and, above all, the *Ruins of Palmyra, or Tadmor in the Desert*, published by Mr R. Wood, who, with M. Bouverie and Mr Dawkins, travelled thither in 1751. More recent travellers have added but little to the information contained in the works here referred to.

Respecting the latitude and longitude there are still various opinions. The estimate which appears to be nearest the truth fixes its situation in long. 38. 50. E. and lat. 33. 20. N. It stands about fifty leagues south-east of Aleppo, as much from Damascus, and twenty leagues west of the Euphrates.

Palnaud.

PALNAUD, a district of the south of India, in the Carnatic, situated chiefly between the sixteenth and seventeenth degrees of north latitude, and on the south side of the river Kistnah. It was ceded to the British in 1801, and is now comprehended in the collectorship of Guntoor.

Palo ‖ Pamiers.

The chief towns are Macheria, Timerycotta, and Currumconda.

PALO, a town of Diarbekir, in Asiatic Turkey, situated on the banks of the Euphrates, and near the edge of a mountain, the summit of which is covered with ruins, from which quantities of old coins and metals are occasionally dug up. The inhabitants amount to 8000, consisting of Turks, Armenians, and Koords. Earthquakes are frequent; and the houses are ill built. The river flows here with an extremely rapid current; and, from the weakness of the wooden bridge, whole caravans have sometimes been swept away when the river was swollen from the melting of the snows. It is sixty miles north of Diarbekir.

PALOS, a reef of rocks in the Straits of Macassar, near the west coast of Celebes. Long. 119. 15. E. Lat. 0. 24. S. There is a town of the same name on the western coast of the island of Celebes, in a bay to which it gives name. Long. 119. 39. E. Lat. 0. 56. S.

PALPAH, a small district of Northern Hindustan, subject to the Ghoorkali rajah of Nepaul, and situated between the twenty-eighth and twenty-ninth degrees of north latitude. To the south it is separated from Oude by extensive woods and forests, and forms one of the numerous principalities subject to Nepaul, called the Territories of the Twenty-four Rajahs. It is intersected by the river Gunduck, and is mountainous and unproductive. The Gunduck is the principal river. Palpah is also the chief town of the district, being situated amongst the mountains that overlook the Gunduck River. Long. 82. 55. E. Lat. 28. 11. N.

PALREE, a town of Hindustan, in the province of Gujerat, situated near the western boundary, between Therah and Theraud. It contains about 250 houses, or rather huts, principally inhabited by Rajpoots.

PALUDAMENTUM, in Roman antiquity, was a habit which differed but little from the chlamys, except that the latter belonged chiefly to the lower class of people. It was worn by the officers and principal men amongst the Romans in time of war, who were therefore called *Paludati;* and this distinguished them from the common soldiers, who, because they wore the *sagum*, were called the *Sagati*. The *paludamentum* came down only to the navel, was open at the sides, had short sleeves resembling angels' wings, and was generally white or red. It is sometimes used to signify the common soldier's coat.

PALUS MEOTIS, the ancient name of a gulf between Europe and Asia, to the north of the Black Sea, and now called the Sea of Asoph.

PALY, or PALE, in *Heraldry*, is when the shield is divided into four or more equal parts, by perpendicular lines falling from the top to the bottom.

PALY *Bende* is when the escutcheon is divided by perpendicular lines, which is *paly*, and also by diagonals, which is called *bendy*.

PAMBOON, a town of Celebes, on the west coast, with an indifferent harbour. It is the residence of a rajah. The inhabitants trade with Macassar and Batavia, and barter the cotton cloth which they manufacture, for gold-dust.

PAMER, a high table-land of Asia, upon the western limit of Little Thibet, and bounded on the west by a mountain ridge of the same name. This ridge joins at its southern extremity the chain of Hindu Coosh, and stretches on the north into the territories of Cashmere, separating Chinese from Independent Tartary.

PAMIERS, an arrondissement of the department of Arriège, in France, extending over 521 square miles. It comprehends six cantons, divided into 115 communes, and contains 67,250 inhabitants. The capital is the city of the same name, the see of a bishop, and the seat of the courts of law for the department. It is situated on the left bank of the river Arriège, in a fertile district, producing much wine. It has a cathedral, three churches, 1000 houses, and 6400 inhabitants, employed in making cotton and woollen goods, and hats. Long. 2. 30. E. Lat. 43. 8. N.

Pampeluna ‖ Pamplona.

PAMPELUNA, or PAMPLONA, a city of Spain, the capital of the province or kingdom of Navarre. It was the place in which the ancient kings of that country held their court, and whence they exercised the mild government of that very limited monarchy. As a strongly fortified frontier town, it has many historical events connected with it in ancient times. Of a recent date, when Bonaparte had resolved on the subjugation of Spain, this place was deemed of so much importance to the success of his cause, that it was seized by an act of treachery, and employed as a depôt for the supplies brought from France. After the French were driven out of Spain, it surrendered to the allied armies. In the civil war which still distracts Spain, it was held by the queen's party, when, from want of pay and provisions, a bloody mutiny broke out amongst the troops, who murdered some of their officers, and compelled others to join them. After a time this mutiny was in some measure appeased; and the queen's general, Espartero, having entered the place, an inquisition was held, when such bloody sacrifices of life were offered as have scarcely ever been known, except in France, in modern times.

In describing this city, a view of it can only be given as it appeared before the recent dreadful events. It is finely situated in the centre of a circular plain, called the Cuença, bordered with hills of no great height, which are projections from the Pyrenean range of mountains. The river Arga runs through and fertilizes the plain, which is highly cultivated, and very productive. It has a castle and fortifications, which are nearly impregnable. The streets are wide and clean, the houses are well built, and the place is most copiously supplied with good water from several fountains. It is the seat of a bishop, and of the provincial government and courts of law. Besides a fine old cathedral, it has four splendid churches, thirteen monasteries, four hospitals, a college, 1650 dwelling-houses, and 14,500 inhabitants. There are, or at least were, manufactures of woollen cloth, of parchment, of leather, of pottery and china ware, and of wax-tapers for churches and chapels. It is in longitude 1. 9. 50. W. and latitude 42. 49. 57. N.

PAMPER, a town of Hindustan, in the province of Cashmere, and district of Vehy, being situated on the north side of the Jhylum River. Long. 73. 13. E. Lat. 34. 19. N.

PAMPHILUS, a celebrated painter of Macedonia, in the age of Philip. He was the founder of the school of painting at Sicyon; and he made a law which was observed not only in Sicyon, but all over Greece, that none but children of noble and dignified persons should be permitted to learn painting. Apelles was one of his pupils.

PAMPLONA, a province of Colombia, in the department of Boyaca. It is separated from Socorro on the south by the river Galinazo or Sogamoso; on the west from Mariquita and Rio Hacha by the great Magdalena; on the north it is bounded by Maracaybo, Rio Hacha, and Merida; and on the east by Varinas, at that part of the country where are collected the waters of the valley of Savateca, the sources of the Apure, a tributary of the Orinoco. The eastern branch of the Andes almost fills this province, and forms numerous valleys, by which the inhabitants easily communicate with the Gulf of Mexico by the Zulia, which forms a confluence with the Catatumba, near the Lake of Maracaybo. The towns situated to the west have likewise easy communications by the Sogamoso and the Canaverales, both navigable rivers. There are other streams besides, which are valuable to Pamplona in an agricultural or commercial point of view. The mineral riches of

Pamplona. this province are little known. It is reported that immense quantities of gold were obtained from the mines of Beta and Montuosa; and, in fact, the remains of great works can still be traced. Now, however, comparatively little is obtained, and that is conveyed to Giron by the waters which form the Canaverales. The sand of this river contains gold of twenty-three carats. There are also silver mines, and the metal which they yield is at the rate of eight ounces to one quintal of ore. The copper mines are rich; but from the very awkward manner in which they have been worked, they have proved of little benefit to the country. The soil of the territory upon which the city of Pamplona is built abounds with mica, which is occasionally found in large sheets, and is split into thin plates, which answer as a substitute for window-glass. Fancy articles of various kinds are likewise manufactured from it. Quartz, felspar, and granite are everywhere met with; and the whole geological features of the country attest the metallic and mineralogical wealth of Pamplona; but from the works being wretchedly conducted, it might as well be at the bottom of the Atlantic.

The soil of this province is upon the whole fertile, but the country remains comparatively a desert, from the indolence of the inhabitants. The district in which the capital is situated produces wheat, oats, maize, celery, cabbages, beans, French beans, and an infinite variety of other vegetables. Here they also cultivate some indigenous plants which are very useful, such as the common pine, the resin of which is used medicinally; the myrica, which produces the wax called laurel; a galium, the root of which furnishes an excellent yellow dye for cottons; and also several other kinds of dye-stuffs. One of the most remarkable spots of this district is Surata, the climate of which place is temperate. Ten thousand loads of meal are annually prepared here, the greater part of which passes through Ocaña, a place dependent on the province of Maracaybo, on its way to Monpox and Carthagena. The wheat is generally of an excellent quality, and affords two crops in the course of the year. At other places in this district wheat, sugar-cane, and rice are cultivated; but in none of the villages, with the exception of those of Mantanza and Ecce-Homo, in the valley of Surata, is sufficient corn gathered to admit of exportation. The olive-tree is very common at Pamplona; but the mode of preparing the oil is either not known or not practised. In the valley of Taupa the nopal is literally laden with the cochineal insects, which are sent into the province of Tunja. Cotton is cultivated in the district of Giron, particularly in the parish of Rio Negro; and great quantities of it are annually sent to Monpox and Carthagena. Near to the parish just named an abundant amber mine has been discovered. The tobacco raised at Giron is of a very superior quality; and the entrepôt established at Piedecuesta contributes to the comfort of the people. Cocoa, of which considerable quantities are disposed of, succeeds very well on the banks of the Sogamoso, Surata, and Canaverales. These countries also furnish large quantities of capaiva balsam, and some building timber. If the road were open from Giron to the Magdalena, this place would enjoy very great commercial advantages. By this means the rocks of the Sogamoso, so destructive to boats, would be avoided; and, besides, a vast extent of unknown lands, situated between the Sogamoso and the Canaverales, would thereby be much frequented. The navigation of this river is far preferable to that of the other, although its waters are too shallow to allow very deeply laden vessels to traverse them. This stream is of great utility to the inhabitants of Rio Negro, who transport their grains by it much more quickly and cheaply than by Ocaña. Great quantities of Brazil wood are found at some places on the Sogamoso; and on the banks of other rivers there are several very fine cocoa plantations. The Cucuta cocoa, called Magdalena cocoa, from its being brought down by that river, is very much esteemed. Coffee and indigo are likewise cultivated in the province, but of much inferior quality to the cocoa. The fertility of the soil is not the only cause of the abundance of the cocoa-trees; the care of the cultivators contributes much to it. Experience has taught them to protect this plant by the shade of the ceibas and erytahrinas, and to surround them with flourishing hedges of citrons, fagaras, and acacias, which are highly ornamental as well as useful. The inhabitants also carefully water the cocoa-trees; but great ravages are committed on them by the *tinea falsa*. This insect is likewise very destructive to the corn and grain of the Surata. A considerable quantity of Cucuta silver passes by San Christoval into the Varinas. It is expended in the purchase of mules and cattle, of which nearly ten thousand head are bought annually; for although the province abounds in pastures which promise sufficient food for immense herds of cattle, yet the climate is very unfavourable to the raising of such stock. However, some horses, mules, sheep, and goats are bred; and a tolerably good morocco leather is prepared from the skins of the last. The dearness of meat causes a scarcity of tallow, for which vegetable wax is used as a substitute. A country which has but few articles to export cannot be accounted very rich; and Pamplona would even be very poor, were it not for the extreme division of property, which is the means of diffusing comfort through a great number of families. The llanos adjoining the valley of Savateca would be an advantageous opening for the grains of the country in exchange for cattle, were there any road to facilitate commercial intercourse. This might, however, be effected by following the direction of the valley watered by the Chitoya, which would appear to be one of the head streams of the Apure. By this means Pamplona would be brought into communication with Guiana. Giron might do so likewise with the distant provinces by the same road; and instead of paying very dearly for the provisions which this town draws from the llanos of Casanare by the salt mine of Chita (that article being chiefly derived from this place or from Zipaquira), it would procure them at a moderate price from those of Varinas. This article carries almost all the specie from Giron. Pamplona.

The most flourishing towns of this province are those of St Joseph and of Rosaria de Cucuta, notwithstanding the disadvantages under which they labour from want of an opening for their productions. Their territory, varied by the valleys watered by the Jachira, the Pamplona, and the Zulia, has some fine cocoa plantations. The appearance of Rosaria de Cucuta is extremely pleasing. Surrounded by rich haciendas in excellent cultivation, it stands as it were in the midst of a delightful garden. The perspective at the extremity of each street terminates in a beautiful vista, with high mountains in the back-ground. The town, which is not large, is neat and well built. The houses have a clean appearance, but are not large. The streets are paved, and have a current of water running through the middle. This town will ever be famed in the annals of Colombia, as the place in which the first general congress was held, and where the constitution was framed. It was also the place understood to have been fixed on as the future capital of Colombia, under the name of the City of Bolivar; but such has not taken place. The town of Salazar de las Palmas has declined in proportion as those of the valley of Cucuta have advanced in prosperity. Some rich parishes, however, particularly St Jago and Cayetano, may be reckoned amongst its dependencies. This town owes its name to the great variety of palms which cover that part of the province where it is situated. The different kinds found here are the royal palm, which affords wine and butter; the negro-head palm, the fruit of which can be worked like ivory; the noli and the murap-

Pan.

po, which latter is used in covering houses, and the twigs of which are eaten. Much of this province, from being traversed by the Andes, is of course very elevated. The town of Pamplona, situated in 8° north latitude, is about eight thousand feet above the level of the sea. This elevation, however, serves to moderate the temperature, which averages about 60° of Fahrenheit. But the climate is by no means agreeable, on account of the vapours which continually darken the heavens. Pamplona is situated in a valley about a league in extent, and is surrounded on all sides by high hills. It possesses a great many churches; and as the houses stand pretty well apart, from each having a portion of garden-ground attached to it, the city at a little distance has a spacious appearance. The surrounding fields are enclosed by stone walls in a very regular manner, imparting to the scene an air of proprietorship which is not often met with. The effect, however, which Pamplona has, as seen from the adjacent eminences, is considerably abated when the town is entered. It exhibits little of its former wealth and importance. Many of the houses are found to be abandoned, the streets are overgrown with grass, and the gardens are neglected. This city was founded by Pedro de Ursua in the year 1549. The gold and copper mines in the vicinity formerly gave it an importance which it does not now possess. The gold mines of Veta, which are within two days' journey of this place, have not been regularly worked for more than a century; but the Indians occasionally bring grains to sell of a considerable size. Not many years ago a mass of pure gold was found which weighed upwards of six pounds. The parish church of Pamplona is reckoned one of the most handsome in the kingdom. The Jesuits had formerly a college here; and there were also several monasteries, which are now abandoned. The population of this town has been estimated at 3200. It is situated 180 miles west-south-west of Merida, 131 west of Varinas, and 270 north-east of Bogota. There appears to be no other place in this province deserving of particular mention. The whole population of Pamplona, consisting of whites, half-whites, and Indians, has been estimated at 75,000. (R. R. R.)

PAN, the god of shepherds, of hunters, and of all country exercises. But he bore a higher character amongst the earliest Greeks, as well as amongst the Egyptians, from whom his worship was borrowed by the former people. In Egypt he was known by the name of *Mendes*, which, according to Jablonski,[1] signifies fecundity. Hence his symbol was a living he-goat, the most salacious of all animals: "Hircum Mendesium colunt Ægypti, eo quod virtuti prolificæ ac genitivæ consecratus est. Namque animal hoc coitus valde cupidum est." His principal temple was a magnificent building in a city of Lower Egypt, called after his name. It is well known, that from dedicating certain animals to certain gods, the Egyptians proceeded to consider the animals themselves as actuated by the divinities to whom they were sacred. Hence, perhaps, the origin of animal worship. In the temple of Mendes was kept a he-goat, to which sacrifices of a very monstrous kind were offered.

The deity whom the Egyptians adored by the name of Mendes was no other than the Soul of the Universe, for he was their most ancient god; and we are told by Plutarch, "that they took the first God and the Universe for one and the same thing."[2] Hence his name of Παν amongst the Greeks. Not that either the Greeks or their masters in theology worshipped, as their first god, mere brute matter, but that spirit which they conceived to be co-eternal with matter, and to animate all things, making them *one*. Thus Orpheus, who imported the Egyptian doctrine into Greece, declares that all things are one; and after him Parmenides and other philosophers taught ἓν εἶναι το παν, that "one is the universe," and that the "universe is immoveable." That the ancient Grecian Pan, or the Egyptian Mendes, was not the corporeal world, as senseless and inanimate, but the whole system of things animated and eternal, appears further from the following testimony of Macrobius: "Hunc deum Arcades colunt, appellantes τον της ὑλης κυριον, non sylvarum dominum, sed universæ substantiæ materialis dominatorem." The Arcadians worship this god, calling him the lord of Hyle, that is, not the lord of the woods, but the lord of all material substance. In the same manner Pharnutus describes the Pan of the other Greeks, not as the mere corporeal world, but as the intellectual principle actuating it and presiding over it; and he adds, that "Pan was feigned to be lascivious, because of the multitude of spermatic reasons in the world, and the continual mixtures and generation of things."

Pan.

The Egyptians, as we learn from Jablonski, had nearly the same notion with the Greeks of the spirit which they worshipped as the soul of the universe, only they ascribed to it both sexes. As the maker, governor, and bountiful father of universal nature, they considered it as a male, whose symbol was the he-goat of Mendes; and as a female it was adored by the name of Isis, to whom the she-goat was consecrated, though not held in such veneration as the male. From this view of the Egyptian creed, the sacrifice which we have mentioned appears no longer unaccountable. It was made to a god, believed to be the universal source of fecundity, and to whom, from the well-known character of the animal which he was supposed to actuate, they had reason to believe that it would be most acceptable.

The Greeks never worshipped their Pan by the emblem of a living goat; but they painted him with the lower parts of a goat, for a reason which will be afterwards mentioned. How he came to degenerate amongst that people, from one of the *Dii majorum gentium*, or rather from the first principle of all things, to the rank of a demon or demi-god, we cannot pretend to say. But that such was his fate is certain, for under this last character mention is made both of his birth and his death.

It is not agreed whose son he was. Homer makes him the son of Mercury, and says he was called *Pan*, from παν, *omne*, because he charmed all the gods with his flute; but others say that he was the son of Demogorgon, and first invented the organ, of seven unequal reeds, joined together in a particular manner. Having upon a time fought with Cupid, the latter in spite made him fall in love with the nymph Syrinx, who, flying from him to the banks of Ladon, a river of Arcadia, was, at the instant prayers of the Nymphs, turned into a reed, as her name in Greek signifies, which the god grasping instead of her, made a pipe of, and for his music was worshipped by the Arcadians. The most common opinion was, that he was the son of Mercury and Penelope. But Naturæ Comes makes his birth scandalous, by saying he was called παν, because begotten by all Penelope's suitors. He was painted half-man half-goat, with large goats' horns, a chaplet of pine on his red face, a pleasant laughter, with the feet and tail of a goat; a motley skin covered his body, and he had a crooked stick in one hand, and his pipe in the other. He is described by Silius Italicus (xiii. 326, *et seq.*) as a sight enough to frighten women and children, nay, even armed men too; for when Brennus the Gaul was about to pillage the temple of Apollo at Delphos, Pan struck such a terror into his army, that he quitted his sacrilegious design; and hence *Panici terrores*. Yet, homely as he was, he pleased the goddess Lu-

[1] *Pantheon Egyptiorum.*

[2] *De Iside et Osiride.*

Pan. na, turning himself easily into a white ram (Virgil, *Georg.* iii. 392, *et deinceps*); and also the nymph Dryope, almost putting off his divinity, and turning shepherd, for her sake. Neither was he displeasing to other nymphs, who are generally represented dancing around him to hear the charms of his pipe. The usual offerings made to him were milk and honey, in shepherds' wooden bowls. A dog, the wolf's enemy, was also sacrificed to him; and hence his usual epithet is λυκαιος, and his priests are called *Luperci.*

His festival, celebrated on the 15th of February by the Romans, was brought into Italy by Evander the Arcadian, and revived afterwards by Romulus, in memory of his preserver. He was also called by the Romans Inuus, *ab ineundo.* (Liv. i. 5; Macrob. *Sat.* i. 21; and Serv. *in Virg. Æn.* vi. 775.) The ancients, by giving so many adjuncts and attributes to this idol, seem to have designed him as the symbol of the universe. His upper parts are human, because the upper part of the world is fair, beautiful, and smiling, like his face; his horns symbolize the rays of the sun and of the moon; his red face indicates the splendour of the sky; the spotted skin wherewith he is clothed, the stars which bespangle the firmament; the roughness of his lower parts, beasts and vegetables; his goat's feet, the solidity of the earth; his pipe, compacted of seven reeds, the seven planets, which, they say, produce the harmony of the spheres; and his crook, bending round at the top, the years circling into one another.

Having said so much of Pan, both as a self-existent god and as a generated demon, we shall conclude this article with some observations on Plutarch's account of the prodigy which happened at his death; for, in the Pagan creed, demons were not all believed immortal. "In the reign of Tiberius," says he,[1] "certain persons on a voyage from Asia to Italy, and sailing towards the evening by the Echinedes, were there becalmed, and heard a loud voice from the shore calling on one Thamus, an Egyptian pilot, whom they had on board. Thamus, as may be supposed, listened with attention; and the voice, after repeating his name thrice, commanded him when he came to the Pelodes, to declare that the Great Pan was dead. The man, with the advice of his companions, resolved, that if they should have a quick gale off the Pelodes, he would pass by in silence; but that if they should be becalmed, he would perform what the voice had commanded. Adhering to this resolution, they soon arrived off the destined islands, and were immediately becalmed, there being neither breath of wind nor agitation of water. Upon this, Thamus, looking from the hinder part of the ship towards the land, pronounced with a loud voice, 'the Great Pan is dead,' and was instantly answered from the shore by numberless howlings and lamentations."

This story, which has so much the air of imposture, has not only been admitted as true by men of the first eminence for learning and acuteness, but has been applied to our Saviour, whose death, says Cudworth, the demons mourned, not from love, but from a presage that it would put a period to the tyranny and domination which they had so long exercised over the souls and bodies of men. In support of this opinion, he quotes several passages of Scripture, such as, "Now is the prince of this world judged;" and, "Having spoiled principalities and powers (by his death upon the cross), he triumphed over them in it." He affirms likewise, that "Pan being taken for that reason or understanding by which all things were made, and by which they are all governed, or for that divine wisdom which diffuseth itself through all things, is a name which might very well signify *God manifested in the flesh.*"

Panama. The authority of Cudworth is great; but a groundless opinion has seldom been propped by weaker reasoning than he makes use of on this occasion. Plutarch indeed says, and seems to believe, that this prodigy fell out during the reign of Tiberius; but as he mentions not the year of that reign, there is no evidence that it was at the crucifixion of our Saviour. The demons who inhabited the Echinedes knew what had been transacted at Jerusalem, far distant from their islands; they knew the name of the pilot of a strange ship; they knew that the mariners of that ship had resolved to disobey their command, unless becalmed off the Pelodes; they had power over both the winds and waves at the Pelodes, and exerted that power to enforce obedience to their command; and yet these all-knowing and powerful beings were under the necessity of calling in the aid of a man to deliver a message to their companions, inhabiting a place to which the very same story assures us that their own power and knowledge reached. Should it be said that the demons were compelled by divine power thus publicly to make known to man Christ's triumph over the kingdom of darkness, we beg leave to ask why they were not likewise compelled to give him another name, since it is certain, that at the era of Tiberius, and long before, illiterate Pagans, such as common seamen must be supposed to have been, knew no other Pan than the fabled son of Penelope and Mercury? Indeed the other Pan, taken for that reason or understanding by which all things were made, could not possibly be the being here meant. For, erroneous as the Pagan system was, there is nothing in it so completely absurd as the death of the soul of the universe, the maker of all things; nor do we believe that any Pagan ever existed, who dreamed that such a death was possible.

What, then, it will be asked, are we to understand by this story? Plutarch was eminent for knowledge and integrity, and he relates it without expressing a doubt of its truth. But many a man of worth has been credulous; and though that was not his character, this prodigy may be accounted for by natural means. Germanicus was believed to have been poisoned, at least with the knowledge, if not by the command, of Tiberius; and there was nothing which the Romans so deeply deplored as the untimely death of that accomplished prince.[2] They fancied that his body was animated, not by a human soul, but by a superior demon; and they decreed to him statues, religious ceremonies, and even sacrifices. His widow was highly honoured, as having been nearly related to a divinity, and his children were adored as demi-gods. These facts being admitted, nothing appears to us more probable than the opinion of the learned Mosheim,[3] who thinks that some shrewd statesman, in order to excite the popular fury against Tiberius to the highest pitch, invented this story, and bribed foreign mariners to spread it amongst the people, who would naturally believe, that by the Great Pan was meant their favourite Germanicus. This hypothesis is at least countenanced by what Plutarch tells us of the anxiety of the emperor to discover what personage could be meant by the Pan whose death was announced to the seamen. He consulted the learned men of Rome, who, in order to restore peace to the city, declared that they understood it of none other than the son of Penelope and Mercury.

PANAGUR, a town or village of Hindustan, in the province of Malwah, and district of Gurrah, 115 miles south from Chatterpoor. Long. 88. 15. E. Lat. 25. 20. N.

PANAMA, Isthmus of (also the name of a province of New Grenada), is that extraordinary ligature or neck of land which connects the continents of North and South America. It is also sometimes called the Isthmus of Da-

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[1] *Lib. de Oracul. Defect.* [2] Tacitus, *Annal.* cap. 72, 83, *et* lib. iii. cap. 1. [3] Cudworth's *Intel. Syst.* cap. iv. note 132.

Panama. rien, a name which, however, is much out of use, and ought to be entirely expunged from geographical works.[1] The isthmus of Panama may be considered as extending from the meridian of 77° to that of 81° west of Greenwich. Its breadth at the narrowest, which is opposite the city of Panama, is not less than thirty miles; and it swells out at either extremity, where it becomes blended with the continental portions of the western world. Its whole extent is not, however, comprised within the limits of the province which bears the same name; for to the north-east, the Mandingo Indians maintain a fierce, and not unfrequently a turbulent independence, to the present day. The continuity of the great chain of the Andes, which, for the most part, traverses the whole continent of America, is twice broken within the limits above defined. The Northern Cordillera exhibits the first indication of depression in the province of Nicaragua; but it again elevates itself in the province of Veragua, where it expands into a very fine table-land. In the eastern part of the province it breaks into detached mountains of considerable elevation, and of the most abrupt and rugged formation. Still farther to the east, innumerable conical mountains make their appearance, only three or four hundred feet in height, and having their bases skirted by plains and savannahs. These finally disappear, and the country becomes almost uninterruptedly low and flat. Again the conical mountains thicken, and becoming connected, form a small cordillera, which runs from about opposite Portobello to the bay of Mandingo, where the second break occurs. The land then continues low for a considerable distance, and abounds in rivers, those on the north side flowing to the Gulf of Uraba or Darien, and those on the south to that of St Miguel; beyond which point the cordillera again raises itself on an extended scale, and enters South America. The general bearing of the mountains in the vicinity of Panama is north-east and south-west. They vary elsewhere, and appear to maintain some relation to the line of coast, although they do not always run parallel to it. Their height is not considerable. Near Panama they do not exceed 1000 or 1100 feet in elevation. East of Portobello, however, they are considerably higher, and are generally covered with a dense and almost impenetrable forest, which grows on a soil of great depth and extraordinary fertility. Mr Webster, another traveller in this region, observes, with regard to the mountains of the isthmus: "The mountains which I enumerated were measured by us, and found to be less than 2000 feet high. The principal ingredients of the hills are hornblende, jasper, hornstone, and trap-porphyry; basalt, agate, and quartz rock. A crumbly arenaceous quartz rock prevails near Chagres, containing iron, pyrites, and lead. The stones at Portobello have the volcanic character; and the sand on the beach is of a black description, like that of Fernando Noronha. The streets of Portobello are paved with basalt nodules. Quartz rock is very abundant throughout the isthmus, in many varieties; several beds of clay, boles, ochres, and fullers' earth, are also to be found." Limestone is the prevailing rock, which is skirted on the south side with indurated clay, and on the north with coral rock. The latter is impregnated with a singular gelatinous matter, which imparts to it the property of firmly adhering under water to whatever it comes in contact with. It is easily dug out of the earth, but on exposure to the air it becomes very hard and close in the texture. It thus forms an excellent building material, as does the indurated clay. Besides limestone, flint, calcedony, jasper, and ironstone are found in the interior; and near Gatun, on the river Chagres, there is a very fine fire-stone of great utility in the construction of grates, furnaces, and other things which require to stand a high degree of heat. In building materials of all kinds, indeed, Panama is unusually rich; but in the precious metals it is poor. In Panama proper only two mines are worked, Santa Rita and Pequeni, both for gold; but their produce is insignificant. They are situated in the mountains near Portobello. In Veragua and Choco, very pure gold is obtained in considerable quantity by washing; copper and iron are abundant; and mercury and tin are also said to have been found. But very little capital is embarked in the respective works, and the total amount obtained, either by mining or by washing, is comparatively small and uncertain from year to year. Panama.

This province abounds in rivers, and in the rainy season every mile of land is intersected by a flowing stream, which carries off the surplus water. These disappear during the summer heats; but the following remain permanently, and are considered by Mr Lloyd as worthy of particular description. On the northern side of the isthmus, and consequently flowing into the Atlantic, are the Chagres, Pequeni, Trinidad, and Gatun, which all unite and form one large river before they reach the ocean; and on the south side, and falling into the Pacific, are the Rio Grande, Caymito or Chorrero, Pacoro, Indio, and Ballana or Chepo. The Chagres rises in the mountains which approach the Bay of Mandingo, a considerable distance to the eastward of Portobello. After traversing a great tract of country, when nearly opposite to Portobello it receives the Pequeni, which comes from the south-east, and is of equal magnitude with itself. The united streams form a noble river, but flowing so rapidly, and broken into so many falls, as to render navigation very dangerous, even for canoes. Its velocity abates as it approaches the sea; and at the town of Cruces, which is twenty-three miles direct from the Atlantic, it seldom exceeds from three to three miles and a half per hour, even in the rainy season. Still nearer to the ocean, it rapidly decreases, so that in summer its current is scarcely perceptible. "Few rivers of its size," says Mr Lloyd, "present more beautiful scenery on its banks than does the Chagres above Cruces. For miles together, it is bounded by enormous, abrupt masses of limestone, of the most curious and fantastic forms; in other parts savannahs extend to the very edge of the river, covered with a particularly fine grass called grammallotti; and the noble bongo tree is seen studding the banks, somewhat in the shape of a well-trimmed yew-tree, but growing to a much larger size. In most places the river is shaded from the sun's rays by a large tree called jigeron, which extends its branches across the river, its leaves being eagerly sought by the fish. The water generally runs over a bed of variously coloured pebbles, and is in summer most brilliantly clear. In many places near its source it is much wider than at its mouth, occasionally breaking into distinct channels, and forming small islands; but in the rainy season these are all connected, and constitute one broad stream, with strong sets and eddies, caused by the abrupt turns, which render its navigation peculiarly perilous." The river Trinidad enters the Chagres about twenty-four miles from its mouth, and is also a large river. It has its origin

[1] We are enabled to present a pretty full account of this hitherto imperfectly described portion of America, from the following circumstance. In November 1827, Mr Lloyd, who had served for some time previously on General Bolivar's personal staff, received from him a special commission to survey the isthmus of Panama, in order to ascertain the most eligible line of communication across it, whether by road or canal. The notes which he made on this occasion have been published in the first volume of the Journal of the Royal Geographical Society; and from the article containing these our account is principally derived. The result of his operations, in so far as they regarded the level of the respective seas, and the elevation of the intervening isthmus, will be found detailed at length in the Philosophical Transactions for 1830, p. 59.

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very near the south coast, not far from the town of Chorrera. Canoes of various descriptions navigate this river as far as a large town called Capua, which lies south-west of Chorrera, and bring down produce to Chagres. As high as Mr Lloyd went up, which was not, however, as far as Capua, he found it about two hundred feet in breadth, from twenty to twenty-eight feet in depth, and without falls or any other impediment to easy navigation. The river Gatun is also of considerable consequence, although neither very wide nor very deep. It rises in the mountains east of Portobello; and crossing both the roads leading from that city to Panama, joins the Chagres in front of the town of Gatun, about eight miles from the sea. Some considerable lakes exist in the vicinity of its embouchure; and although it is shallow and encumbered with trees during its course, it is very useful as a shelter for shipping during tempestuous weather. With the united assistance of all these rivers, the navigation of the Chagres below the junction of the Trinidad is easy, and very superior to that of some streams of much larger size. The depth below Gatun varies from twenty-six to thirty feet; above that it is twenty-four, and nowhere falls permanently below twenty-two. The banks are wooded to the very edges, and so precipitous that vessels can almost everywhere be brought close to them. The Rio Grande rises to the north-west of Panama, near a mountain called Pedro Miguel, and after receiving some considerable tributaries, becomes navigable for large canoes two leagues above its mouth, which is about two miles from the city of Panama. It is obstructed by a bar, but the tide rising eighteen feet in spring floods, vessels readily enter and find good anchorage within. In some places the Rio Grande very nearly approaches the Obispo, one of the affluents of the Chagres; and much interest was consequently at one time taken in the circumstance, from an idea that the long-wished-for communication between the two oceans might thus be effected. The shallowness of the stream, however, presents an insurmountable objection to this plan. The Caymito, or Chorrera, falls into the Pacific ten miles west of Panama, and is formed by the union of numerous insignificant streams, which take their rise in different parts of the western cordillera. The mouth of this river is not obstructed by a bar, but the tide runs so strongly into and out of it, that the anchorage for shipping is bad, and exposed. It is infested by a prodigious number of alligators, and hence its name, Caymito. Before reaching the Pacific, the Pacora and Indio unite, near the island of Chepillo, about eighteen miles east of Panama, and form a broad, rapid, and winding stream for several leagues above its mouth. On the banks of the Indio an English resident in Panama erected a saw-mill, capable of sawing from fifteen to twenty thousand boards annually. An inexhaustible supply of the finest timber is found in its immediate vicinity; and so great is the fertility of the soil, that a small portion only, laboured by two men, is sufficient to supply ample subsistence for the whole establishment. The river Ballano or Chepo is of great extent, and, under the name of Canada, rises in the province of Darien, near the source of another river called Chucunaque, which falls into the Pacific in the Gulf of San Miguel. The Bellano receives several streams during its course, which is nearly west, and in some degree parallel to the coast for many miles, until it suddenly turns to the southward, and enters the Pacific a few miles east of the Pacora. It is navigable as far as this bend; and on its banks, a little higher up, is situated the town of Chepo, which is of some consequence, as being the assigned place of communication with the Mandingo Indians. Farther on is a fort called Fuerte Terrible, built to prevent their incursions; and the line of the river generally is considered the boundary.

There are two seasons in Panama, namely, summer or the dry, and winter or the rainy season. The former commences about the end of December, and lasts till April; and the latter occupies the intervening months. The quantity of rain which thus falls during the year is prodigious, but its amount varies at different places. The clouds chiefly congregate over the wooded heights, in consequence of a law of nature which universally prevails. At Portobello, which is closely encircled by them, the rain descends in torrents, frequently accompanied by storms of thunder and lightning, terrible and grand in the highest degree. Where the ground, however, is level to any extent, and has been cleared of its wood, a great difference is perceptible; and at Panama the following alternations have been observed. "In April the weather becomes cloudy about noon; but, after drizzling for half an hour, clears up. In May, from nine to eleven, it is dull, with slight rain; the afternoons being still fine. In June there is rain every morning and evening; but the mid-days are fair. As the season advances the rain gradually increases, and is incessant throughout July, August, September, and October. In November the nights are always wet and cloudy, but throughout the days the sky begins to break. December brings a further improvement; and in January, February, and March, a shower of rain is as uncommon as a gleam of sunshine at the other season of the year." One very remarkable phenomenon occurs throughout the whole isthmus. On the 20th of June the rain ceases for five or six days, when the sun shines forth with surpassing splendour; nor is any instance known of irregularity in the recurrence of this extraordinary phenomenon. It is accordingly reckoned on with great confidence by the inhabitants, who call it El Veranito, or little summer, and celebrate the occasion by a jubilee of rejoicing. The temperature and salubrity of the climate also vary in different places. Portobello is one of the hottest and most unhealthy places in the world. At Panama, on the contrary, the thermometer, in the rainy season, does not rise higher at night than 82°, and in the day than 87° of Fahrenheit. The winds are variable and cool; and although the rain is incessant, there is thus no stagnation in the atmosphere, and consequently no epidemic sickness. In summer the temperature rises to 90°, and even as high as 93°; and during the day the reflection of the sun from the smooth surface of the Pacific, with the heat of the winds, which blow steadily from the south-east, over a tract of dry savannahs, makes it very sultry. But the land-winds, which come chiefly from the neighbouring mountains at night, are cool, and the climate may be pronounced generally healthy, although great mortality at times prevails. It is believed, however, that this may be attributed to over-indulgence in the use of some articles of diet, which are unusually abundant at certain seasons of the year.

It appears that a large proportion of the soil of the isthmus of Panama is exceedingly fertile, and the vegetable productions are most luxuriant. In Mr Lloyd's opinion, it challenges competition with any other part of the world in the vigour and variety of its woods. That gentleman gives a list of about a hundred kinds of wood, of excellent or at least good quality, and which are either unknown or little known in Europe. A number of these are very hard and close grained; some resemble box, which must render them very valuable; and others are similar to birch, beech, ash, elm, and those trees which are familiar to us. There are also cotton trees, cedars, lignum-vitæ, a bastard mahogany, fustic, calabash, and so forth. The fruits and esculent vegetables found in the isthmus are those of similar intra-tropical situations. The grains cultivated are rice and Indian corn. The sugar-cane is grown, but not extensively. Coffee and cocoa are cultivated as required for home consumption. The milk-tree (*palo de vacca*), vanilla plant, and caoutchouc tree, are all abundant in the

Panama. woods. With the gum which flows from the last-named production, while it is yet in a liquid state, the inhabitants manufacture a sort of water-proof cloth, on the same principle as in this country; but which, thus prepared, is more uniform in its texture, and never cracks. The charcoal made from many of the trees is considered as excellent for smelting; and as such is exported to Peru, where it is in much request. Indeed, from the hardness of much of the wood, the excellence of the charcoal made from it was to be inferred. The barks of some of the trees are medicinal, or abound in tannin. Ink is made both from gall-nuts and from a bush resembling the caper, called alsifax. Other trees yield very rich and brilliant dyes used by the Indians, but, Mr Lloyd believes, as yet unknown in commerce. Many valuable resins are obtained, particularly one distilled from the bark of a tree called palo santo, or holy tree, which is highly fragrant, and is used not only as a remedy for disorders, but is burned as incense. The styrax officinalis of Linnæus is very abundant, the gum extracted from it selling for two dollars a pound.

The wild animals of the woods are tigers, or rather tiger-cats, which are seldom larger than small Newfoundland dogs; lions, at least so an animal resembling the king of the forest is called; bears; racoons; sajinos, a species of wild boar found in droves; wild hogs in herds; conejos, something like our rabbits, but larger; deer in abundance on the borders of the woods; multitudes of monkeys of various species; together with wild turkeys, both black and coloured; birds resembling our hen-pheasants; pigeons, ducks, and other game, all excellent for food. The most formidable animals are the wild dogs, which, when together in droves, and fired upon, will readily attack one or two men. The tiger does not attack the human species, but preys upon the smaller animals. On the banks of the Pacora, at its mouth, a wild animal is found called macho, or danta, nearly of the size and appearance of a jackass, which, prepared, is considered a great dainty. The isthmus enjoys a bad celebrity for snakes and poisonous reptiles; but the observations of Mr Lloyd do not go to confirm this report. The country people, however, stand in great awe of them, and will seldom move abroad after nightfall, lest they should encounter them. They even go so far as to wear charms round their necks for the protection of their persons. A great pest in the country are what are called ganapatas, or ticks, which, in half an hour's walk in summer, will completely cover the person, and are with difficulty loosened from their hold. There are other smaller insects, very numerous and annoying, amongst which mosquitos are in the usual abundance. Fire-flies are common, and very brilliant; with many other insects, which Mr Lloyd apprehends have not yet found their way into entomological catalogues. Amongst the domestic animals, and those chiefly used for food, are oxen for draught and slaughter, horses, mules, goats, pigs, fowls, and fish. The breed of cattle is of a good size; and the draught-oxen, when well broken, fetch from twenty-five to thirty dollars each. The best of those for slaughter may be bought at from twelve to eighteen dollars each. The race of horses is small, but hardy, and their price varies from fifteen to forty dollars. Mules are the animals most prized in the country; for, as is well known, no other animal is ridden in mountainous districts. Their price sometimes reaches as high as 120 dollars; but they can be obtained for less money. Goats are not so plentiful as might have been expected; but as they are in great request in the West Indies, it is to be inferred that they are exported there whenever they attain the proper size, so that comparatively few on an average remain at Panama. Pigs are few, and of most exorbitant value. When of a good size, and well fattened, they fetch from thirty to thirty-five dollars each. Fish and fowl are plentiful, cheap, and much used; and in Panama market hundreds of young sharks, of the kind denominated shovel-nosed, and from one to two feet and a half long, are daily sold for food. The guana is considered an especial dainty, as are pearl oysters, and many varieties of game, which are brought in from the woods. Even the monkey tribes are eaten, especially in the country bivouacs, although they are seldom offered for sale in the town markets. The chief articles of farinaceous food are maize and rice; yet the home growth of either seems to be rather limited for so fine a region. The greater part of the sugar used in the isthmus is imported in skins from Central America, or from the valley of Cauca, by way of Buonaventura, on the Choco coast, and is consequently very dear. The home produce is chiefly miel or molasses, and raspadura or pan-sugar, which the inhabitants prefer to the finer preparations of the article. Great quantities of wild honey are gathered in the woods, the bees collecting which do not sting, and are thus robbed without precaution. Panama.

The communication across the isthmus is maintained chiefly by two lines of road; one from Panama to Portobello, and another equally from Panama, by way of Cruces, to Gorgona, down the Chagres, to the seaport of the same name at its mouth. There are some others in use, but little known, and under the Spaniards their improvement and multiplication were much discouraged. Mr Lloyd strongly recommends a new line to be formed, differing from them all, and beginning on the Atlantic at a fine bay called Limon or Navy Bay, about five leagues east from Chagres. From this he proposes it should proceed to the river Chagres, some miles above its mouth, where its course approaches this bay by a canal; thence up the river to a favourable situation on the south bank of the Trinidad, where its shores are excellently suited for being converted into wharfs and landing places, both for goods and cattle; and thence finally to Panama or Chorrera by a railroad, the latter being the shorter distance, but the former the preferable route, both as conducting to a better seaport, and as terminating in Panama, the capital and the centre of trade. Mr Lloyd's reasons for suggesting this innovation will be found detailed at length in the article to which we have already referred. The present roads are exceedingly bad, and they traverse a mountainous part of the country. That between Panama and Portobello is in this respect greatly the worse of the two, being in many places almost impassable in the rainy season, from the steepness of the ascents and descents. But the roads to Cruces and Gorgona also lead across a mountainous country, and are extremely difficult in bad weather; a considerable part of the latter, indeed, being merely the bed of what is in winter a large stream.

The isthmus of Panama is divided into two provinces, viz. Panama which includes the Darien, and Veragua. These again are divided into cantons, having a certain number of parishes in each. According to a census taken in 1822, the latest which we have been able to obtain, the following was the state of the population in the two provinces.

Province of Panama.—The canton of Panama, which comprehended eight parishes besides the capital, contained 16,724 souls; the canton of Chorrera, containing four parishes and the capital Chorrera, 7411 souls; the canton of Los Santos, containing eight parishes and the capital Los Santos, 21,348 souls; the canton of Nata, containing four parishes and the capital, 17,108 souls; the canton of Portobello, containing four parishes and the capital, 2425 souls; and the canton of Darien, containing seven parishes and the capital Tavisa, 1172 souls.

Province of Veragua.—The canton of Santiago, containing six parishes and the capital, 14,170 souls; the canton of Remedios, containing three parishes and the capital, 5010 souls; the canton de la Mesa, containing three pa-

Panama. rishes and the capital, 8722 souls; and the canton of Alange, containing six parishes and the capital, 7465 souls. The summary of the province of Panama gives the total number of inhabitants as 66,188, and that of Veragua as 35,367. The total population of the whole isthmus was 101,550 in the year 1822, nor has it altered to any great extent since. Most of these cantons, with the exception of Portobello and Darien, which are almost uncultivated, are alike in their resources; but distinct reports of the produce of each were not obtained by Mr Lloyd. The population is distributed into white and coloured; and most of the descendants of mestizoes, and even mulattoes, are considered as white, provided they be in easy circumstances. Wealth is here a powerful charm in dissolving caste. One person in every five has a house, or, in other words, the average number in a family is five. From the excess of births above deaths in one of the cantons, that of Los Santos, it appears that the rate of increase is one and a half per cent., which is low when compared with that of the United States, for instance, where the increase exceeds three and approaches four per cent. Of the houses, almost a half are marked as belonging to the country, which indicates at once security and the prevalence of agricultural occupations. Mr Lloyd thinks that the canton of Los Santos may be taken as a fair specimen of the others; with the exceptions already stated, and also that of Panama, the presence of the capital and the emporium of trade giving a preponderance in its favour. In general, however, the western and central districts, with the islands in the Bay of Panama, are the best cultivated and most populous, Los Santos being one of them. Elsewhere the landlords keep their estates chiefly in grass, to save trouble; and the population is nowhere industrious, although strong and enduring under occasional fatigue. The extreme fertility of the soil is one of the main causes of the general indolence; for with a small expenditure of labour, a man can procure a respectable subsistence for himself and family. They are, however, quite susceptible of steadily practising habits of industry when the stimulus employed is powerful enough to call forth their energies. "There are within the province," Mr Lloyd observes, "several regiments of militia, formed of the lower classes of people and Indians, excellent workmen in felling timber and clearing ground, and particularly apt in acquiring any mechanical art." They are exceedingly simple in their habits, and are easily maintained, so that, in the projected communication between the Pacific and Atlantic Oceans, workmen will be obtained at a cheap rate; a circumstance of very great importance to the success of the undertaking.

The capital of the isthmus is Panama, the site of which has been once changed. The old city stood about three miles east from the present situation; and, on the first arrival of the Spaniards in 1515, it was occupied by an Indian population, who were attracted to the spot on account of the vast abundance of fish on the coast, and gave the name of Panama to their place of residence, that word in their language signifying "much fish." The natives, however, were speedily dispossessed by their ruthless invaders; and, as early as the year 1521, the title and privileges of a city were conferred on the Spanish town by the Emperor Charles V. In the year 1670, old Panama was reduced to a heap of ruins by the pirate Morgan; and it was after this catastrophe that the city was built on the spot where it now stands. Panama is situated in latitude 8. 57. north, and longitude 79. 30. west from Greenwich, on a rocky tongue of land shaped nearly like a spear-head, extending a considerable way into the sea. Its harbour is protected by a number of islands lying at a little distance from the mainland, and some of which are of considerable size, and highly cultivated. These spots upon the sea, scattered around the Bay of Panama, are the gardens of the town, and afford a plentiful supply of fruit and vegetables. There is good anchorage under the lee of all of them; and, besides the productions of the soil, good water can be obtained from nearly the whole of them. The plan of the city is somewhat irregular; but the principal streets extend across the peninsula, which allows a current of air freely to circulate; and the rules for cleanliness are here more strictly observed than is usual in Spanish American towns. The fortifications which encircle the town are neither regular nor strong, although the walls are high, and the bastions have been constructed from time to time, as circumstances required that the place should be protected. The buildings are of stone, and generally most substantial, those of a large size having patios or courts. They are constructed in the old Spanish style. Amongst edifices of a public nature may be mentioned a beautiful cathedral, four convents, now nearly or altogether deserted, a nunnery, a college de la Compania, and also the walls of another, which was begun on a magnificent scale, but was never finished, and is now crumbling to ruins. Immediately around Panama, eastward along the coast, and north-westward from it, the land is low and flat; but westward and north-eastward, the mountains approach it closely; and, from a hill in the vicinity, about six hundred feet in height, a view may be obtained of the sea with its islands, and the country with its forest-mantled mountains, and its green savannahs. The beach is fringed with plantain and banana trees, growing amongst oranges, figs, and limes, and numberless rich shrubs, shaded by the tamarind, which crowns them all, except the cocoa-nut, with its feathery top and naked stem. Panama is celebrated for its gold chains, in the manufacture of which the natives are remarkably expert. The hat which goes by the name of this city, and is a favourite head-dress in the country, is brought from Guayaquil, and costs from two to twenty dollars. This city enjoyed a long period of prosperity; but it has materially declined since America cast off the Spanish yoke. Yet it possesses advantages in regard to situation which may yet be turned to great commercial account; and Panama may still be restored to more than its former opulence and splendour. The population amounts to nearly 11,000.

Portobello is situated in latitude 9. 34. 35. north, and longitude 77. 45. west, close to the sea, at the foot of immense mountains, which surround the whole of the port. It consists of one long street, which environs the bay, and from it smaller ones branch off where the ground renders this practicable. There are, besides, two squares, one in front of the treasury, which is built of stone; and another formed on one side by the church, which is also of stone, and a capacious edifice, considering the smallness of the population. It has been allowed, however, to fall into ruin; and the same may be said of all the public and most of the private buildings. The hospital, and even the fortifications, are dilapidated; and of the houses in town only a few remain tenantable. Portobello has an unhappy notoriety for the insalubrity of its climate, and has acquired the title of the Sepulchre of Europeans. The heat is most oppressive, and the town being closely environed by mountains, the freshness of the sea-breezes is never felt. Immense forests also cover the mountains, and the denseness of their foliage excluding the sun's rays, the earth remains moist, and a thick unhealthy vapour is continually exhaling, which collecting in clouds, covers the town like a pall, and keeps up an almost perpetual rain. Not only the human species, but even the lower animals, degenerate, and cease to produce in this Golgotha; so that not a cattle-estate is to be found in its vicinity, all the meat consumed being brought from Panama. The mountains and forests, which abound with animals of various kinds, extend to the very foundations of the houses, so that it is no uncommon thing to find wild hogs and

Panama. small tigers usurping the abodes of man. Toads of a large size are also so abundant, that after a night of rain they cover the streets like a living pavement, and it is impossible to walk without crushing them. The population is now extremely limited, about eleven hundred; the greater part being negroes and mulattoes, with a few old Spaniards, tenacious of their property, and who are rapidly dying out. Occasionally a few visitors from Panama arrive with goods, which they dispose of at an exorbitant rate; and a small detachment of troops is sent from the capital to do duty for a short time.

Chagres is a miserable place, about thirty-two miles west from Portobello. It is situated in a little sandy bay, at the mouth of the river Chagres, on its north side, and consists of an assemblage of dirty, rude, ill-conditioned huts, built of reeds. From the nature of the surrounding country, it is open to no wind but a westerly one, and is thus, like Portobello, extremely unhealthy. A castle, in which ten guns are mounted, protects the mouth of the river and the small harbour. The inhabitants are chiefly black or coloured, with the exception of a few custom-house officers, and the commandant of the castle. They are said to amount to about two thousand in number. Chagres and Portobello are the only towns or villages on the Atlantic shore of the isthmus; and, as we have seen, they are of a very inferior description. About nine miles east from Chagres is Navy Bay, called also the Bay of Limon. It is large and spacious, being three miles in width at the entrance. The other towns of Panama are of little importance. Gatun is but a small village. Gorgona is somewhat larger, being a point where passengers going to the capital frequently land. Cruces, however, is the place to which goods are always conveyed. It is pleasantly situated on a fine open plain, upon the left or southern bank of the river Chagres, about thirty-four miles from its mouth, and eight hours' ride from Panama. The inhabitants of these places are nearly all owners of canoes or mules, or store-keepers for taking charge of goods, or bagas, that is, persons employed in working canoes. Cruces and Gorgona are also resorted to in summer as watering-places by the inhabitants of Panama, being considered very healthy; and the town of Chorrera, situated upon the river of that name, enjoys the same advantage.

The trade on the Atlantic shore of the isthmus is maintained with Jamaica by a British man-of-war, which sails monthly for the purpose of conveying letters and specie; with Carthagena by government vessels, twice a month; and with the same and a few other points by independent traders, which bring freight to Chagres, and there exchange it. On the Pacific side it embraces all parts of the coast, both north and south, which find it their interest to communicate with Europe in this way. Specie is conveyed across the isthmus to be embarked at Chagres at an expense of ten dollars two reals for every five thousand dollars or ounces; and there is, besides, a transit duty of three per cent. on silver, and one per cent. on gold. Return goods are brought to Panama, where they are lodged in the custom-house immediately on their arrival. If for exportation, they pay a duty of two per cent.; and if for home consumption, according to the nature of the article. The trade of the isthmus is very limited, but it is believed to be improving. The financial affairs of the government of Panama stood thus in 1827:—Receipts, 241,682 dollars; expenditure, 238,929 ditto; leaving a balance in the treasury of 2753 dollars. The income is not one third of what it was in 1812, when Panama was attached to Spain; but this arose from that exclusive system of dealing which was universally practised by that power.

The upper classes in the isthmus belong to the common stock of Spanish America, but are by no means so far advanced in civilization as their neighbours. The white people, and particularly the women, who are exceedingly retired in their manners, are noted for a tinge of the European complexion, which is scarcely to be looked for from their geographical position. They are very superstitious and illiterate, children being brought up in the very worst manner. Hence, although there is a well-conducted college at Panama, the blessings which it would otherwise diffuse are greatly counteracted by the negligence with which parents superintend their offspring, allowing them to associate indiscriminately with the lowest negroes of their own age. They thus acquire habits of gambling and other kinds of low vice; the first being the curse of the country, and indeed of almost every part of the former dominions of Spain in the western world. The inhabitants display a considerable turn for commerce; and, from the highest to the lowest, each keeps a shop or tienda. The lower classes also pursue different handicrafts; but, with the exception of goldsmiths' work, to which we have already alluded, they are rude in all. The field for this branch of art, however, as for every other which contributes to luxury, is now much curtailed. But the dress of the women, on occasions of religious processions or rejoicings, is still very splendid. They decorate their persons with a profusion of ornaments, amongst which pearls are conspicuous for their number and brilliancy. These are procured amongst the islands off the coast, by diving, which is pursued as a favourite occupation, although both very laborious and uncertain. Panama.

By the last arrangement affecting this country, it forms the north-western boundary of New Grenada, one of the three republics into which Colombia separated in the year 1832.

We are unwilling to enter at any length into the much agitated question of a communication between the Atlantic and Pacific Oceans, because it is at present only a matter of speculation, and, from all appearances, the work will be one of distant and very uncertain fulfilment. There are no less than five plans by which it is proposed to effect this junction. Beginning with the most northerly, it has been suggested that the Gulf of Mexico might be united to the Gulf of Tehuantepec in the Pacific, by means of a canal which should join the sources of the Chimilapa to those of the Rio del Passo. The distance (thirty-eight leagues), and other circumstances, render this plan by no means a favourite. Its realization is more important to the state of Mexico than to the general interests of the commercial world. By the second and third plans, the lines of communication pass through Central America, and a notice of them will be found in the article NICARAGUA. The communication through the Isthmus of Panama has occupied more attention than any of the others; and although it will not answer for a ship-canal, it presents great facilities for transferring merchandise from one ocean to the other, at a trifling expense, by a river and canal sufficiently deep for steam-boats. Mr Lloyd's attention was chiefly directed to the practicability of a railroad along the level country between the mouth of the Trinidad and the town or river of Chorrera; and no doubt this work would be very beneficial. But many persons are of opinion, that by deepening the Obispo, and the Mandingo, which flows into it, and then connecting these rivers by a canal with the Rio Grande, at the point whence it is navigable to the Pacific, the desired object would be attained fully as well as by the plan of Mr Llyod. The distance from the Chagres, at the point where the Obispo enters it, to the Rio Grande, is twelve miles; and the Obispo, at its junction with the Mandingo, or nearly at that part, approaches to within four miles and a half of the Rio Grande, the interval between the two rivers presenting no serious obstacle, and being nearly flat. This is certainly the shortest route; but whether it is practicable, or is even the best,

Panamao Isle || Panaroo-can.

remains to be determined by proper surveyors and engineers. Before individuals sent out in these capacities shall have examined the country and published their reports, no correct judgment can be formed upon the merits of the several plans. A question here arises, and it is one which ought to be deliberately discussed before anything is done in the matter, namely, should the communication be of that limited nature which would render it necessary for the goods to be transported by smaller craft or by railroads from one vessel in the Atlantic to another in the Pacific; or ought it to be a large ship-canal, capable of admitting vessels of deep draught, and thus effectually uniting the two oceans at once? Such a plan is said to be practicable at the isthmus of Cupica; and this is the last of the five which we mentioned as having been proposed. Humboldt, who is a great authority, is of opinion that Cupica Bay merits the serious attention of men of science, from the great facilities it presents for solving the problem of a ship-canal. The scheme is simply to connect Cupica Bay, in the Pacific, with the large river Atrato, flowing into the Atlantic, by forming a canal across the interval, which is ascertained to be a perfect level. The course of the river Naipi, before its confluence with the Atrato, intersects this level country within five leagues of the Bay of Cupica. The Atrato flows through the province of Choco, in which it rises, and reaches the Atlantic at the southern end of the Gulf of Darien, in the Bay of Choco.

One thing is certain, that were such a communication between the two great oceans effected, it would prove of incalculable utility to all nations engaged in maritime commerce, and sooner or later it will unquestionably be opened. Geographically, this would be nearly the shortest possible route from Europe, North America, a great part of Asia, as well as from Africa to every port on the western coast of the New World. With regard to the more obvious saving of space to be travelled over, we need say nothing; a glance at a map of the world will show at once what would be gained. Therefore, although only the smaller work were carried through, there would be an immense saving in time, by the greater certainty of good and safe passages in a voyage from Panama to Canton, Australia, and every port and island in the Pacific Ocean, notwithstanding the necessity for disembarkation and transhipment. But the advantages of a canal of sufficient size to allow large vessels to proceed right across the isthmus would be incomparably greater. They must, however, be so obvious to every mind, that we need not enlarge upon them in this place. But by whom is either of the two works to be accomplished? The question is not a British one alone, nor even an European; it is more particularly an American question, though the whole commercial world would be more or less remotely affected by it. It is not likely, therefore, that any individual nation will be so generous as to undertake the expense on its own account; and there must be either a joint-stock company of governments formed, who will agree to defray so much each of the expenditure, or a joint-stock company of individuals, who will accomplish some one line of communication or another, and indemnify themselves for their outlay by planting tolls upon it. (R. R. R.)

PANAMAO ISLE, one of the Philippine Islands, about fifteen miles in circumference, and of a triangular form. Long. 124. 15. E. Lat. 11. 27. N.

PANAON, or PANAHAN, is one of the Philippine Islands, about forty-five miles in circumference. It is well watered by numerous streams that flow from the mountains. Long. 125. 12. E. Lat. 10. 7. N.

PANARAGA, a town of the island of Java, and capital of a kingdom, situated on the southern side of the island. It is sixty miles east of Mataran.

PANAROOCAN, a town of Java, in the north-eastern extremity of the island, situated on a river which enters the sea by several mouths. It was formerly the capital of an ancient principality, but is now subject to the Dutch. It has a square fort, built with palisades and planks, and which stands about three quarters of a mile from the sea, in a marshy plain. Long. 114. E. Lat. 7. 40. S.

Panathenæa || Panchberarah.

PANATHENÆA, Παναθηναια, in Grecian antiquity, an ancient Athenian festival, in honour of Minerva the protectress of Athens. Harpocration and Suidas refer the institution of this festival to Erichthonius IV. king of Athens, who lived before Theseus. Theodoret alone says that the feast was established by Orpheus. But be this as it may, till the time of Theseus it was never a particular feast of the city of Athens, and was simply called *Athenæa;* that prince, however, having united all the people of Attica into one republic, they afterwards assisted at the festival; and hence the name *Panathenæa*, or the feast of all Attica. In effect, all Attica was present; and each division of the people sent a bullock for the sacrifices, and for the entertainment of the vast multitude of people assembled.

There were two festivals under this denomination; the greater and the lesser. The greater Panathenæa were exhibited every five years; the less, every three years, or, according to some writers, annually. Though the celebration of neither employed at first more than one day, yet in after times they were protracted for the space of many days, and solemnized with greater preparations and magnificence than at their first institution. The ceremonies were the same in the greater and the lesser Panathenæa; excepting a banner, on which the actions of the goddess were represented in embroidery, executed by maids, with the names of those who had distinguished themselves in the service of the republic. This only was borne at the greater. Prizes were established for three different kinds of combat. The first consisted of foot and horse races; the second, of athletic exercises; and the third, of poetical and musical contests. These last are said to have been instituted by Pericles. Singers of the first class, accompanied by performers on the flute and the cithara, exercised their talents upon subjects prescribed by the directors of these exhibitions.

PANAULON, an enlarged German-flute, with sixteen finger-keys, and descending as low as G in the treble clef, with two ledger lines under the stave. It was invented a few years ago by Trexler of Vienna. To remedy its inconvenient length, the lower end was curved. The quality of its tone is not so good as that of the common German-flute; but still the panaulon may be effectively used in orchestra music, as a bass to the other flutes.

PANCARPUS, in Roman antiquity, a kind of show which the Roman emperors frequently exhibited to the people. The word is formed from the Greek παν, *all*, and καρπος, *fruit;* and hence the name was also given by the Athenians to a sacrifice, in which all kinds of fruits were offered. In this spectacle, the circus being all set over with large trees, represented a forest, into which the beasts being admitted from the dens under ground, the people, at a sign given by the emperor, pursued, shot, and killed all they could lay hold of, which they afterwards carried away to regale upon at home. The beasts usually given on these occasions were boars, deer, oxen, and sheep.

Casaubon, Cujas, Pithou, and others, represent the *pancarpus* and *sylva* as the same thing; but Salmasius thinks they were different. The *sylva*, according to him, was such a diversion as that above described; but the *pancarpus* was a combat in which robust people, hired for that purpose, fought with wild beasts. This opinion Casaubon confirms from Cassian, Justinian, Claudian, Firmicus, Manilius, and Cassiodorus.

PANCHBERARAH, a town of Hindustan, and small

Panco Point || Pandects.

district, in the province of Cashmere. Long. 75. E. Lat. 34. 32. N.

PANCO POINT, a remarkable cape, situated at the north-eastern extremity of the island of Java, at the mouth of the western entrance of the Straits of Madura. Here are stationed Javanese and European pilots, who, as soon as vessels are seen standing for the channel, go before to pilot them to Gressee and Sourabaya. Long. 112. 44. E. Lat. 6. 48. S.

PANCRAS, a large parish formerly detached from the metropolis by wide and open fields, but now a great portion of the northern side of London. Within the last forty years it has been covered with large houses, composing some of the handsomest squares, and the widest and most uniformly built streets. The parish is very extensive, including a third of Highgate, the several hamlets of Battle-Bridge, Kentish Town, Somers Town, Cambden Town, and Tottenham Court Road, as far as Rathbone Place. The houses in the newly-built portion are not generally large, and many of them are small but neat; and as the rent is lower than in many other parts of the western portion of London, they are occupied by people of inferior wealth. Those houses which are of the superior kind are found, from their vicinity to the inns of court and the courts of law, to be appropriately adapted for persons in some way or other connected with the law, though many of them are filled by the families of mercantile men from the city. The old parish church is small, and still retains somewhat of its rural appearance. It is remarkable as the favourite burying-place of the Roman Catholics, and a very large proportion of the grave-stones exhibit a cross and the letters R. I. P., *requiescat in pace*, or, may he rest in peace. Two new churches have recently been erected, one of which, on the new road, is made the parish church, and is amongst the most magnificent of those new edifices. The growth of the parish may be seen from the population returns, thus: In 1801 the inhabitants amounted to 31,779, in 1811 to 46,333, in 1821 to 71,838, and in 1831 to 103,548.

PANCRATIUM (compounded of *παν*, *all*, and *κρατιω*, *I overcome*), amongst the ancients, a kind of intermixed exercise, consisting of wrestling and boxing; but it differs in this, that as the athletæ were not to seize the body, their hands were not armed with gauntlets, and gave less dangerous blows.

The *pancratium* was the third gymnastic exercise, and was not introduced till long after the others. The people who were engaged in these exercises were called *pancratiastæ*; a name which was also given to such as did not confine themselves to one exercise, but succeeded in several different ones.

PANCSOVA, a city of Hungary, in the province of the Hungarian frontier, the capital of the limits or circle of the German Banat regiment, which extends over 1656 square miles, comprehending the city and sixty villages, with 101,200 inhabitants. The city is situated upon an arm of the Themes, at its influx into the Danube. It contains 960 houses, and 8640 inhabitants, who carry on considerable commerce with their Turkish neighbours. Long. 20. 32. 2. E. Lat. 44. 49. 40. N.

PANDA, in *Mythology*, a goddess who was invoked and honoured as the protectress of travellers and navigators. The goddess of peace was also called Pandar, because she opened the gates of cities which were shut in time of war. According to Varro, Panda is a surname of Ceres, formed *a pane dando*, because she gave bread to mankind.

PANDAR, a small town of Hindustan, in the Sikh territory, and province of Lahore, 132 miles north-east from the city of Lahore. Long. 75. 16. E. Lat. 33. 17. N.

PANDECTS, PANDECTÆ, in jurisprudence, the digest or collection, made by Justinian's order, of 534 decisions or judgments of the ancient lawyers, on as many questions occurring in the civil law; to all which that emperor gave the force and authority of law, by the epistle prefixed to the collection. The word is Greek, *Πανδεκται*, being compounded of *παν*, *all*, and *δεχομαι*, *I take*; that is, a compilation, or a book containing everything relative to public and private rights. Others, however, as Bartoli, think it was formed from *παν*, and *δεχομαι*, because these books were supposed to contain the whole doctrine of the civil law. See the article CIVIL LAW.

Pandiculation || Panel.

PANDICULATION is that violent and extensive motion of the solids which usually accompanies the act of yawning.

PANDIWORA, a village of Hindustan, in the province of Gujerat, near to which flows a stream of clear but salt water.

PANDORA, in fabulous history, a woman formed by Prometheus, to whom each of the gods gave some perfection. Venus bestowed upon her beauty; Pallas, wisdom; Juno, riches; Apollo, music; and Mercury, eloquence. But Jupiter being displeased at Prometheus for having stolen fire from heaven to animate the mass he had formed, gave Pandora a box, which she was enjoined not to open; and then sent her to the earth with this box, in which were enclosed age, disease, pestilence, war, famine, envy, discord, and all the evils and vices that could afflict mankind. This fatal box was opened by Epimetheus, brother of Prometheus, when instantly all the diseases and mischiefs with which it was filled spread over the earth, and Hope only remained at the bottom. Hesiod says Pandora was the first woman.

PANDORA, a small kind of lute, with fewer strings than the ordinary lute. It is believed to have originated in the Ukraine, where it is used to accompany vocal music, or to play national and Polish dances. Some writers are of opinion that this instrument was known to the ancient Egyptians, and that amongst them it had three strings.

PANDURA, a Neapolitan instrument, of a larger size than the mandola, and strung with eight metal wires. It is played with a quill. The pandurina was an instrument of a similar kind, with four strings, but is now disused.

PANEGYRIC, an oration in praise of some extraordinary person or virtue. The name is Greek, *πανηγυρις*, being composed of *παν*, *all*, and *ἀγειρω*, *I assemble*; because anciently in public and solemn assemblies of the Greeks, either at their games, feasts, fairs, or religious meetings, panegyrics were pronounced. To render these the more solemn, the Greeks used to begin with the praises of the deity in whose honour the games were celebrated; next they descended to the praise of the people or country where they were celebrated; then they lauded the princes or magistrates who presided at them; and, lastly, they bestowed eulogies on the champions, especially the conquerors, who had gained the prizes in them.

PANEGYRICUM, in church history, an ecclesiastical book, used by the Greek church, containing the panegyrical orations of various authors, on the solemnities of Jesus Christ and the saints. It is found in manuscript in most churches, but it is not the same in all, each church having its particular saints; indeed the compilers of this kind of books usually suited their collections to the taste of their own devotion. They are disposed according to the order of the months, and frequently consist of twelve volumes, answering to the twelve months of the year. Amongst the principal authors of this work are Athanasius, Cyril, Basil, Chrysostom, and others.

PANEL (*panella*, *panellum*), according to Sir Edward Coke, denotes "a little part;" but the learned Spelman says that it signifies *schedula vel pagina*, a schedule or roll, as a panel of parchment, or a counterpane of an indenture; but it is used more particularly for a schedule or roll, containing the names of such jurors as the sheriff re-

Panela ‖ Panionia.

turns to pass upon any trial. Hence the *impanelling* a jury is the entering their names in a panel or little schedule of parchment.

PANELA, or PANNELA, a town and fortress of Hindustan, in the province of Bejapore. It is one of the strongest fortresses in India, which was taken by the celebrated Mahratta chief Sevajee, by stratagem, in the year 1660. It was subsequently besieged in vain by the army of the king of Bejapore; and yielded to the powerful arms of Aurungzebe about the year 1670. It was near this place that the British ambassador, Sir W. Norris, had his audience of Aurungzebe in 1701. Long. 74. 20. E. Lat. 17. N.

PANGANSANE ISLE, an island in the Eastern Seas, situated off the south-eastern extremity of Celebes, fifty-two miles in length by sixteen in average breadth. It is low, level, and covered with fine trees.

PANGOOTARRAN, one of the Sooloo Archipelago Isles, in the Eastern Seas, about ten miles in length by four in average breadth. It is one entire bed of coral rock, with scarcely any appearance of soil on it. It abounds, however, in cocoa-nut trees, and has also plenty of cattle, goats, and fowls. Long. 120. 30. E. Lat. 6. 9. N.

PANHA, a village of Hindustan, tributary to the Nepaul rajahs, in the province of Serinagur. It contains forty or fifty huts. Long. 79. 10. E. Lat. 30. 18. N. About six miles to the south of this place are the copper mines of Dhanpoor, and eight miles to the north those of Nagpoor.

PANIANY, a seaport town of the south of India, in the province of Malabar. It is situated on the south bank of the Palicaud River. It consists of about 500 houses belonging to traders, and 1000 huts inhabited by the lower classes of people, and forty mosques. It is very irregularly built; many of the houses are two stories high, built of stone, and thatched with cocoa-nut leaves. The houses are scattered over a wide extent of sandy plain; the river, though wide, has a bar at its mouth, which only admits the entrance of boats. The inhabitants are generally of the class of Mahommedans called Moplays. They were formerly very rich, and possessed vessels that sailed to Surat, Mocha, Madras, and Bengal. But they were reduced to great poverty by the oppressions of Tippoo Sultan. The exports from Paniany are teak timber, pepper, rice, corn, and cocoa-nuts. The chief imports are wheat, pulse, sugar, spices, &c. Paniany was taken possession of by the British troops under Colonel Humbertson in 1782. It was afterwards recovered by Tippoo, with whom it remained till the conclusion of peace in 1792, when, with the province of Malabar, it was annexed to the British possessions. It is forty miles south by east from Calicut. Long. 76. E. Lat. 10. 44. N.

PANIC denotes an ill-grounded terror or fright. Polyænus says it originated from Pan, one of the captains of Bacchus, who with a few men put a numerous enemy to route, by a noise which his soldiers raised in a rocky valley, favoured with a great number of echoes. This stratagem making their number appear far greater than it was, the enemy quitted a commodious encampment, and fled. Hence all ill-grounded fears have been called *panics*, or *panic fears;* and it was this that gave occasion to the fable of the nymph Echo being beloved by the god Pan. Others derive it from the circumstance, that in the wars of the Titans against the gods, Pan was the first who struck terror into the hearts of the giants. Theon on Aratus says he did it by the means of a sea-shell, which served him for a trumpet.

PANIONIA, in *Antiquity*, a festival celebrated in honour of Neptune, by a concourse of people from all the cities of Ionia. In this festival, if the bull offered in sacrifice happened to bellow, it was accounted an omen of divine favour, because that sound was thought to be acceptable to Neptune.

PANMELODICON, an instrument invented by Leppich at Vienna in 1810. By means of a conical barrel moved by a wheel, rods of metal, bent to a right angle, were made to sound when the finger-keys were pressed down.

Panmelodicon ‖ Panorama.

PANNAH, a town of Hindustan, in the province of Allahabad, and district of Bundelcund, celebrated for the diamond mines in its neighbourhood, which, during the reign of Akbar, produced L.100,000 a year. It is thirty miles south-east from Chatterpore. Long. 80. 17. E. Lat. 24. 43. N.

PANNARIA, one of the group of the Lipari Islands, in the Mediterranean Sea. It was called Thermissia by the ancients, on account of its natural warm baths. It is about seven miles in circumference, and contains 200 inhabitants, who cultivate a rich volcanic soil. There is a good port on the south side for small vessels, called Calla de Castello.

PANNIPUT, a town of Hindustan, in the province of Delhi. It is about four miles in circumference, and was formerly surrounded with a brick wall, which partly remains. In the centre of the town is the shrine of a Mahommedan saint, who flourished during the fourteenth century. The surrounding district is fertile in sugar, and a considerable trade is carried on by the town in that article, and in salt and grain. It is celebrated as the scene of two of the greatest battles ever recorded in the history of Hindustan. The first was in the year 1525, between the army of Sultan Baber and that of the Delhi Patan Ibrahim Lodi, in which the latter was defeated and slain. The second, which was still a greater and more decisive action, took place between the combined Mahommedan army, commanded by Ahmed Shah Abdalli, king of the Afghans, consisting of 80,000 cavalry and infantry, and eighty pieces of cannon, and that of the Mahrattas, commanded by Bhow Sedasiva, nephew of the peishwa, who had under him about 70,000 regulars, with 15,000 Pindarries, and nearly 200 pieces of cannon. The Mahrattas were completely overthrown, and the whole host nearly destroyed; so that they were never able again to contend with any hope of success for the dominion of India. It is fifty miles north by west from the city of Delhi. Long. 75. 50. E. Lat. 29. 23. N.

PANORAMA. A panorama is a picture drawn on the interior surface of a large cylinder, representing the objects that can be seen from one station, when the observer directs his eye successively to every point of the horizon. A picture drawn on a vertical plane in the usual way includes only that portion of the sphere of vision that can be seen from one point opposite to the picture, without turning the eye; this portion may comprehend about thirty degrees of the horizon, because the field of distinct vision when the eye remains unmoved is concluded in a cone the angle at the apex of which does not exceed thirty degrees. There are compositions comprehending the visible hemisphere, and sometimes nearly the whole sphere of vision; and in these, one connected scene is represented on the interior surfaces of a polyhedron, or of a curved solid, the point of sight being in the centre of the polyhedron, and the eye being turned round on its centre, to each of its surfaces, in order to view the whole scene. Of this kind are the gnomonic projection of the sphere on the interior surfaces of a cube, and several pictures, in which one connected subject is represented on the ceiling and the sides of a room; such as the picture of Jupiter fulminating the giants, by Julio Romano, on the walls and hemispherical ceiling of a round room in the Palazzo del T, at Mantua; and the architectural representations and ornaments in Raffaelle's Loggia in the Vatican. Objects are also sometimes projected on the interior surface of a sphere, the eye being placed in the centre; as in a large hollow sphere with the constellations, which was constructed at

Panormo ‖ Pantænus.

Pembroke College, Cambridge. These projections, where the eye, remaining in the point of sight, is turned round on its centre to view the different parts of the picture, are formed on the same principle as the panorama.

The cylindrical surface is the most convenient for panoramas of landscapes; and the specific employment of a large cylindrical surface for representing the landscape of the whole circle of the horizon, is the invention of Mr Barker, who brought the panorama into use, and still continues to exercise his art. The cylinder on which the panorama is painted is commonly about sixty feet in diameter. The projection or perspective of a panorama is formed by imaginary lines drawn from different points of the surrounding objects, to the point of sight in the axis of the cylinder. The intersections of these lines with the cylindrical surface form the corresponding points in the panoramic picture. Where the picture is projected on a plane, as in common perspective, and in the gnomonic projection of the sphere, the cones formed by imaginary lines or rays passing from the point of sight to the different objects are cut by the plane of the picture; consequently, the sections being formed by a plane, are curves, of which the curvature is always simple. In the perspective of the panorama, where the picture consists of the intersection of the cones of rays by a cylinder, these intersections are, in many of the cases, doubly curved curves. When the picture of a straight line, which is neither parallel to the horizon nor to the axis of the cylinder, is drawn on the cylinder of the panorama, the picture of the line is part of an ellipse, because the oblique section of a right cylinder, by a plane passing through the axis, is an ellipse; when the cylinder is developed and unrolled on a plane surface, this ellipse becomes the curve called the sinical curve. The projection of lines on the interior surface of a cylinder is also employed in drawing Mercator's charts. But in the projection of the panorama, the field extends only a few degrees above and below the horizon, whereas, in the projections of the sphere, the field extends many degrees on each side of the plane, which is at right angles to the axis of the cylinder. In drawing a panorama, as well as in drawing a picture on a plane, the horizontal angles between different objects may be observed by a plane table or theodolite; and the elevation of the objects above the horizon, or their depression, may also be observed by the theodolite. The horizontal angles are to be laid down by setting off on the graduated horizon of the cylindrical picture the number of the degrees observed; the vertical angles on the cylinder are the tangents of the angles observed, the radius being the semidiameter of the cylinder. (B. B.)

PANORMO, a town of Asiatic Turkey, in Anatolia, on the south coast of the Sea of Marmora. It is sixteen miles south-east of Artaki.

PANOU, a river of Asiatic Russia, which falls into the Niznei Tunguska. Long. 102. 24. E. Lat. 64. 40. N.

PANTÆNUS, a Stoic philosopher, born in Sicily about the beginning of the reign of Commodus. He presided over the celebrated school of Alexandria, where, from the time of St Mark, the founder of that church, they had always a divine who was eminent for his learning and piety to explain the Holy Scriptures, and to instruct them in human learning. This employment he was obliged to leave; for when the Indians required of Demetrius, bishop of Alexandria, to send them one to instruct them in Christianity, he sent Pantænus, who undertook the mission with joy, and behaved himself very properly in it. It is said that the Indians had been tinctured with Christianity by St Bartholomew the apostle; and that Pantænus met with the Hebrew original of St Matthew's gospel, which the apostle had left there. St Jerome says that Pantænus brought it with him, and that in his time it was preserved in the library of Alexandria. But we suspect that St Jerome is mistaken in this respect. When Pantænus returned to Alexandria he re-assumed the government of the school of that city, which he had probably during his absence committed to the care of St Clement, a presbyter of Alexandria. He explained the Scriptures publicly, under the reign of Severus Antoninus Caracalla, and, in St Jerome's opinion, was more serviceable to the church by his discourses than by his writings. He published some commentaries upon the Bible, which are lost. That the prophets often express themselves in indifferent terms, and that they make use of the present time instead of the past and future, is a rule of Pantænus, which has been followed by all succeeding interpreters. Theodorus has related this rule; but he speaks of it as if Pantænus had rather said than written it. We may have some notion of Pantænus's manner of explaining the Scriptures by the similar performances of St Clement of Alexandria, Origen, and others who were brought up in that school.

Pantalone ‖ Pantheism.

PANTALONE, an instrument invented about the end of the seventeenth century, by Hebenstreit, a German. It resembled the German psaltery, was of an oblong shape, and had two sound-boards, the one furnished with metal wires, the other with gut-strings. Its compass was the same as that of the harpsichord.

PANTALOON, a sort of garment consisting of breeches and stockings of one piece, and said to have been first introduced by the Venetians.

PANTALOON, in the theatre, is a buffoon or masked person, who performs high and grotesque dances, and shows violent and extravagant postures and airs. The word is likewise used for the habit or dress which these buffoons usually wear, and which is made precisely to fit the body, being all of a piece from head to foot.

PANTELLARIA, an island in the Mediterranean Sea, belonging to the kingdom of Naples, between Sicily and Cape Bon in Africa, seventy-two miles south of Maritimo. It is about thirty miles in circumference, and is entirely volcanic, consisting of vestiges of lava, pumice, scoriæ, and puzzolana. The interior consists of hills covered with brush-wood, and valleys well cultivated with vines, cotton, and fruit, especially raisins, but not yielding corn sufficient for the inhabitants. The capital is Oppedulun, a large but very poor place. It has a haven, defended towards the sea by a castle and another battery, and is convenient for small vessels, who load with wine, oil, cotton, archil, raisins, and some alum. The population of the island is 4600 persons, tolerably active, but of lax morality, many being fugitives from the law in other parts of the Neapolitan dominions. Near Sataria Point are some grottos, called stoves, which emit vapours deemed efficacious in the cure of some diseases. Long. 11. 54. 20. E. Lat. 36. 51. 15. N.

PANTHEA, in *Antiquity*, were single statues, composed of the figures or symbols of several different divinities. Joubert, who calls them *pantheæ*, and has remarked them sometimes on medals, says that their heads were most commonly adorned with the symbols or attributes belonging to several gods. An instance of this appears in a medal of Antoninus Pius, representing Serapis by the bushel, the Sun by the crown of rays, Jupiter Ammon by the ram's horns, Pluto by the large beard, and Æsculapius by the serpent twisted in his hand. Baudelot, in his dissertation on the Lares, observes, that the *panthea* had their origin from the superstition of those who, taking several gods for the protectors of their houses, united them all in the same statue, by adorning it with the several symbols proper to each of these deities.

PANTHEISM, a philosophical species of idolatry, leading to atheism, in which the universe was considered as the supreme God. The inventor of this absurd system is not known; but it was of early origin, and variously modi-

Pantheon. fied by different philosophers. Some held that the universe was one immense animal, of which the incorporeal soul was properly God, and the heavens and earth the body of that God; whilst others held but one substance, partly active and partly passive, and therefore looked upon the visible universe as the only *Numen*. The earliest Grecian Pantheist of whom we read was Orpheus, who called the world the body of God, and its several parts his members, making the whole universe one divine animal. According to Cudworth, Orpheus and his followers believed in the immaterial soul of the world; therein agreeing with Aristotle, who certainly held that God and matter are coeternal, and that there is some such union between them as subsists between the souls and bodies of men.

In the ancient Orphic theology, we are taught that this universe, and all things belonging to it, were made within God, that all things are contained together in the womb of God; that God is the head and middle of all things; that he is the basis of the earth and heaven; that he is the depth of the sea, the air we breathe, the force of the untameable fire; that he is the sun, moon, and stars; and that there is one divine body, for,

Παντα γαρ ἐν μιγαλω τῳ δι σωματι κιιται,

"all these things lie in the great body of God." But, further, to prove that the most ancient Greek philosophers resolved all things into God, and made God *all*, το παν, we shall cite a most remarkable passage from Plutarch's Defect of Oracles. "Whereas there are two causes of all generations, the divine and the human, the most ancient theologists and poets attended only to the more excellent of these two; resolving all things into God, and pronouncing this of them universally:

Ζιυς ἀρχη, Ζιυς μισσα, Διος δ' ἐκ παντα πιλονται,

'that God is both the beginning and middle, and that all things are out of God;' insomuch, that they had no regard at all to the other natural and necessary causes of things; but, on the contrary, their juniors, who were called naturalists, deviating from this most excellent and divine principle, placed all in bodies their passions, collisions, mutations, and commixtures."

That by the most ancient theologists here mentioned, Plutarch meant Orpheus and his immediate followers, is plain from the Orphic verse by which he proves their antiquity. By their juniors, whom he calls naturalists, he could mean no other than the first Grecian philosophers, Anaximander, Anaximenes, and Hippo, who were followed by the atheistical atomists, Leucippus, Democritus, Protagoras, and Epicurus. But with respect to the universe being God, and all things, divine and human, being modifications of mere matter, the Stoics undoubtedly agreed with Anaximander and his followers; for the school of Zeno held but one substance. This impious doctrine, that all things are God, and that there is but one substance, was revived in modern times by Spinoza, an apostate Jew. See Spinoza.

PANTHEON, a beautiful edifice at Rome, anciently a temple, dedicated to all the gods, but now converted into a church, and dedicated to the Virgin and all the martyrs. (See Rome.)

This edifice is generally thought to have been built by Agrippa, son-in-law to Augustus, from an inscription on the frieze of the portico. Several antiquaries and artists, however, have supposed that the Pantheon existed in the times of the commonwealth, and that it was only embellished by Agrippa, who added the portico. But be this as it may, the Pantheon, when perfected by Agrippa, was an exceedingly magnificent building; the form of the body being round or cylindrical, and its roof or dome spherical. Within, it is 144 feet in diameter; and the height from the pavement to the grand aperture on the top, through which it receives the light, is just as much. It is of the Corinthian order. The inner circumference is divided into seven grand niches, wrought in the thickness of the wall, six of which are flat at the top; but the seventh, opposite to the entrance, is arched. Before each niche are two columns of antique yellow marble, fluted, and of one entire block, making in all fourteen, the finest in Rome. The whole wall of the temple, as high as the grand cornice inclusive, is cased with different sorts of precious marble in compartments; and the frieze is entirely of porphyry. Above the grand cornice arises an attic, in which were wrought, at equal distances, fourteen oblong square niches; between each niche there were four marble pilasters, and between the pilasters marble tables of various kinds. This attic had a complete entablature; but the cornice projected less than that of the grand order below. Immediately from the cornice springs the spherical roof, divided by bands which cross each other like the meridians and parallels of an artificial terrestrial globe. The spaces between the bands decrease in size as they approach the top of the roof; to which, however, they do not reach, there being a considerable plain space between them and the great opening. That so bold a roof might be as light as possible, the architect formed the substance of the spaces between the bands of nothing but lime and pumice-stones. The walls below were decorated with lead and brass, and works of carved silver; and the roof was covered on the outside with plates of gilded bronze. There was an ascent from the springing of the roof to the very summit, by a flight of seven stairs; and, if certaina uthors may be credited, these stairs were ornamented with pedestrian statues ranged as an amphitheatre. This notion was founded on a passage of Pliny, who says that Diogenes the sculptor decorated the Pantheon of Agrippa with elegant statues, yet that it was difficult to judge of their merit, upon account of their elevated situation. The portico is composed of sixteen columns of granite, four feet in diameter, eight of which stand in front, with an equal intercolumniation all along, contrary to the rule of Vitruvius, who is for having the space answering to the door of a temple wider than the rest. On these columns there is a pediment, the tympanum of which was ornamented with basreliefs in brass; and the cross beams which formed the ceiling of the portico were covered with the same metal, as were also the doors. The ascent up to the portico was by eight or nine steps.

In the reign of Tiberius, the Pantheon was considerably damaged; but it was repaired by Domitian, from which circumstance some writers consider him as the founder of the building. The Emperor Hadrian also did something to the edifice. But the Pantheon was more indebted to Septimius Severus, than to any one besides. The most, perhaps, that any of his predecessors had done, was adding some ornament to it; Septimius bestowed upon it essential reparations.

This temple subsisted in all its grandeur till the incursion of Alaric in the time of Honorius. Zozymus relates, that the Romans having engaged to furnish this barbarian prince with three thousand pounds weight of gold and five thousand pounds weight of silver, upon condition that he should depart from their walls; and having found it impossible to raise those sums either out of the public treasury or by private contribution, they were obliged to strip the temples of their statues and ornaments of gold and silver. It is probable that the Pantheon supplied a good part, as that of Jupiter Capitolinus was the only one in Rome that could vie with it in riches. Alaric carried off nothing from the Romans besides their precious metals. But, thirty-nine years thereafter, Genseric king of the Vandals took away part of the marbles; and whether from greed of plunder, or from a relish for the productions of art, he loaded

Pantheon.

one of his ships with statues. It cannot be questioned that on this occasion the Pantheon was stripped of more of its ornaments, and that the inestimable works of Diogenes became the prey of this barbarian.

Before these predatory visits of the Goths and Vandals, the Christian emperors had issued edicts for demolishing the Pagan temples. But the Romans, whatever were their motives, spared the Pantheon, which is known to have suffered no damage from the zeal of the pontiffs, or the indignation of the saints, before the first siege of Rome by Alaric. It continued so rich till about the year 655, as to excite the avarice of Constantius II., who came from Constantinople to pillage the Pantheon, and executed his purpose so far as to strip it both of its interior and exterior coverings of bronze, which he transported to Syracuse, where they soon afterwards fell into the hands of the Saracens.

About fifty years before this, Boniface IV. had obtained the Pantheon of the Emperor Phocas, in order to convert it into a church. The artists of those days were totally ignorant of the excellence of the Greek and Roman architecture, and spoiled every thing they laid their hands upon. To this period are to be referred certain alterations, of which we shall immediately have occasion to speak.

After the devastations of the barbarians, Rome was contracted within a narrow compass. The seven hills were abandoned; and the Campus Martius, being an even plain, and near the Tiber, became the ground-plat of the whole city. The Pantheon happening to stand at the entrance of the Campus Martius, was presently surrounded with houses, which spoiled the fine prospect; and it was still more deplorably disgraced by some of them which stood close to its walls.

From the time when Constantius carried off the brass plating of the exterior roof, that part was exposed to the injuries of the weather, or at best was but slightly tiled in, till Benedict II. covered it with lead, which Nicholas V. renewed in a better style. It does not appear that from this time till that of Urban VIII. any thing remarkable was done for the Pantheon.

Raffaelle, who had no equal as a painter, and who was also an architect, left a considerable sum by his will for the reparation of the Pantheon, where his tomb is placed; and Perino de la Vagua, Jacomo Udino, Annibale Caracci, Flamingo Vacca, and the celebrated Corelli, did the same. All the ornaments within which have any claim to be called good, are of later times. The paintings merit esteem; and the statues, although not masterpieces, do honour to sculpture, which alone is a proof that they are posterior to the fifteenth century.

Pantheon || Pantiku.

But, with all the respect due to a pontiff who was otherwise a protector and friend of the arts, it were much to be wished that Urban VIII. had never known that the Pantheon existed. The inscriptions cut at the side of the door inform us that he repaired it; yet, whilst he built up with one hand, he pulled down with the other. He caused two belfries constructed in a wretched taste to be erected on the ancient front-work, and he divested the portico of all the remains of its ancient grandeur, namely, the brazen covering of the cross beams, which amounted to such a prodigious quantity, that not only the vast canopy of the confessional of St Peter's was cast out of it, but likewise a great number of cannon for the castle of St Angelo.

Alexander VII. did what Urban VIII. had neglected to do. Whilst Bernini was constructing the colonnade of St Peter, this pontiff ordered search to be made for pillars to match those of the portico of the Pantheon; and some were found not far from the French church of St Louis, which were of the very same model. They were granite of the isle of Ilva or Elba, and those of the portico were Egyptian granite; the colour, however, was the same, so that the effect was equal. Nor did the pontiff's zeal stop here. He caused all the old houses before the portico to be pulled down, and the soil and rubbish which covered the steps, and even the bases of some of the pillars, to be cleared away. He began covering the roof with marble, and raised a lantern over the aperture, to keep out rain; but death removed him before his project was completed. Clement IX. his successor, enclosed the portico within iron rails. Several later popes have added to its decorations, which were all in the taste of the times when they were executed; and the body of the edifice and its architecture gained nothing by them. The main object of the liberality of the pontiffs was the embellishment of the grand altar. One sent purple curtains, another bestowed silver tabernacles, and others gave vases and superb dresses, suited to the solemn ceremonies of religion. All these might be called rich; but they had in no sense a tendency to retrieve the ancient majesty or original splendour of the temple. The true gusto of the ornaments was a little imitated at the revival of the arts. Good statues replaced the skeletons and squat figures which had disgraced the altars for the space of eight centuries. The paintings of Perugino and others covered the dull mosaics with which the Greeks of Constantinople had loaded the walls of most of the churches in Rome. The porphyry and the green and yellow antique found amongst the old ruins were likewise employed to much advantage.

PANTIKU, a village of Asiatic Turkey, on the north-eastern coast of the sea of Marmora.

END OF VOLUME SIXTEENTH.

Printed by Thomas Allan & Co.,
and Balfour & Jack,
and Stereotyped by Thomas Allan & Co.

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[illegible] a village of Asiatic Turkey [illegible] the sea of Marmora.

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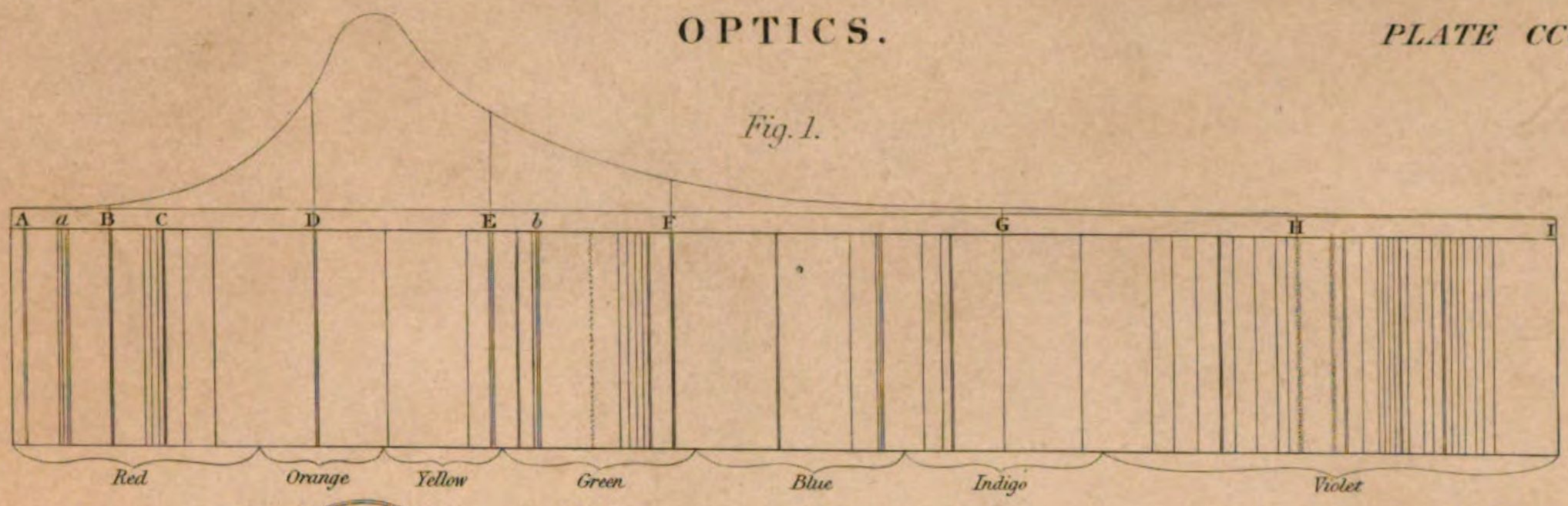
Fig. 1.



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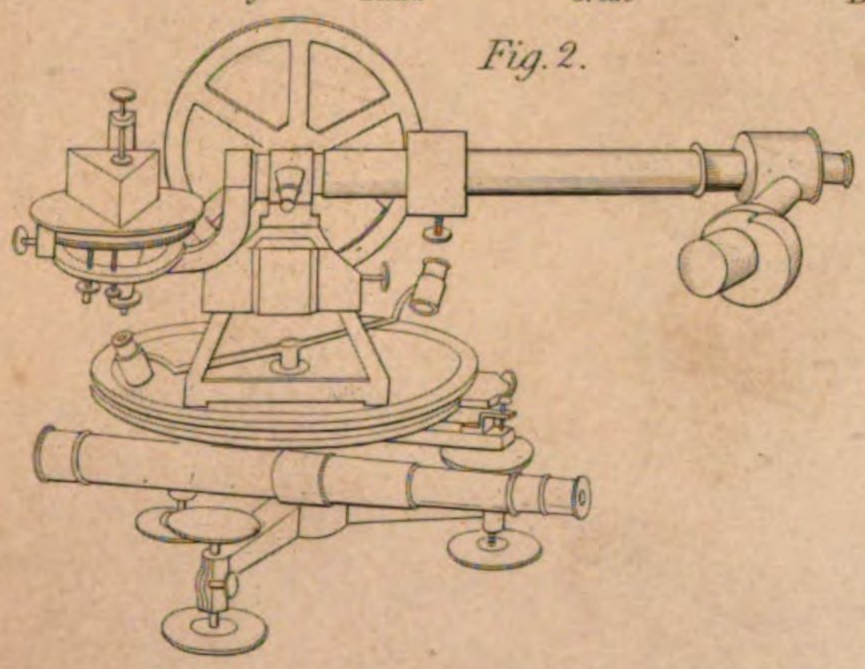

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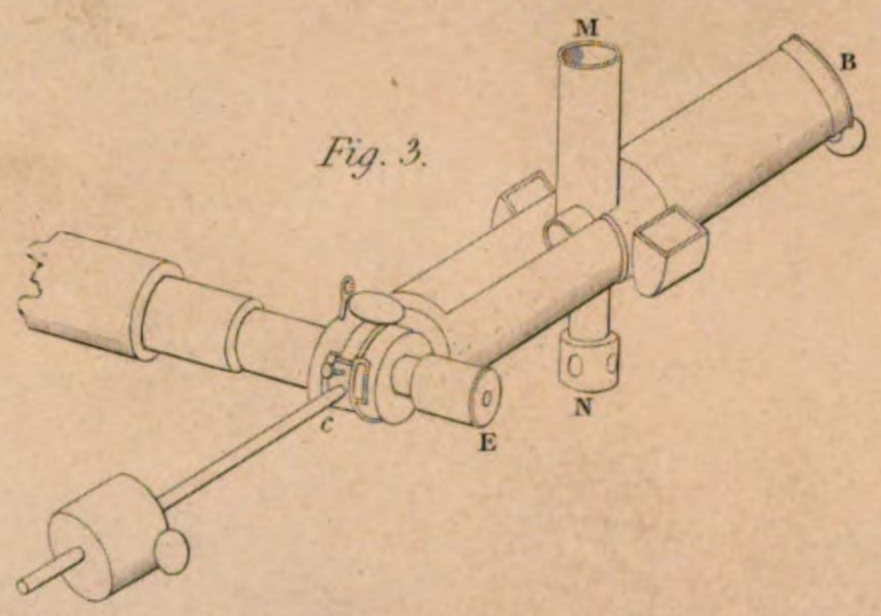

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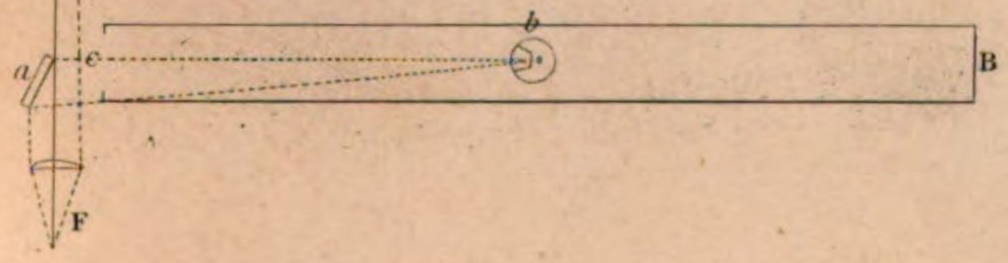

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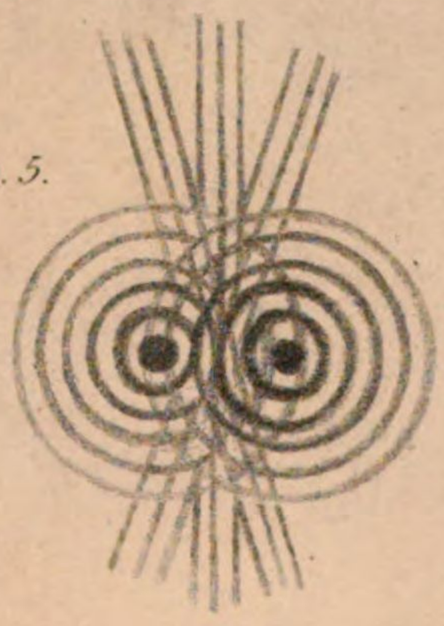

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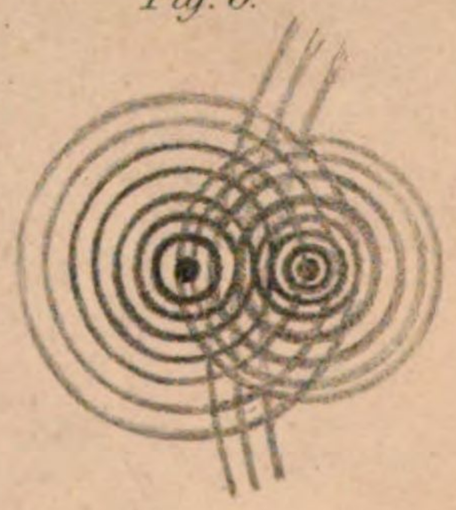
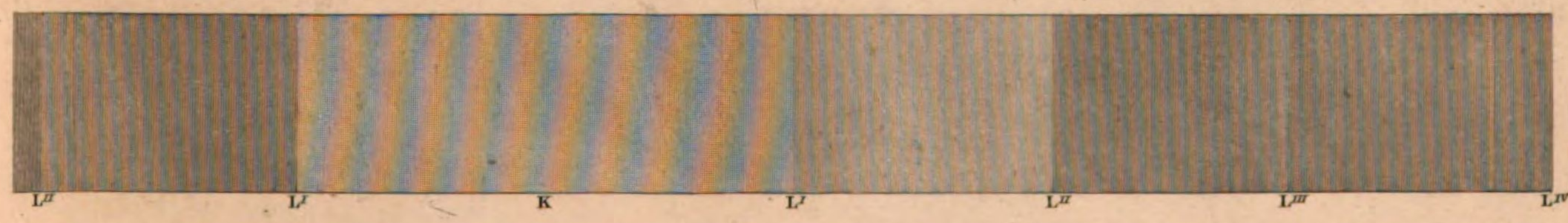


Fig. 7.



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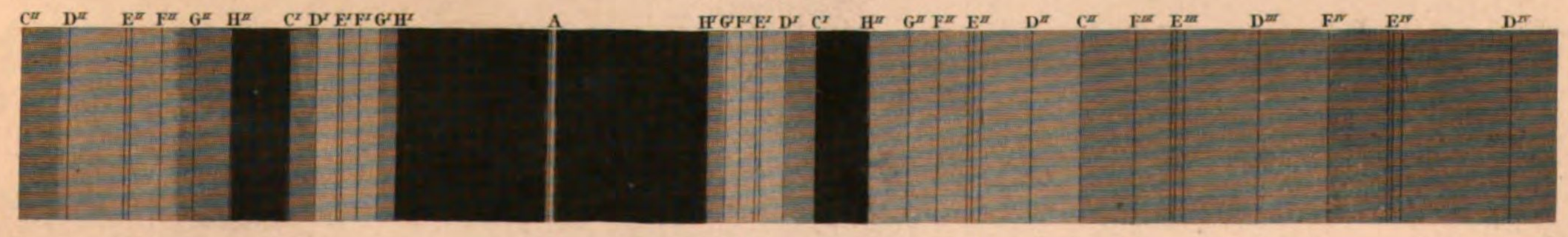

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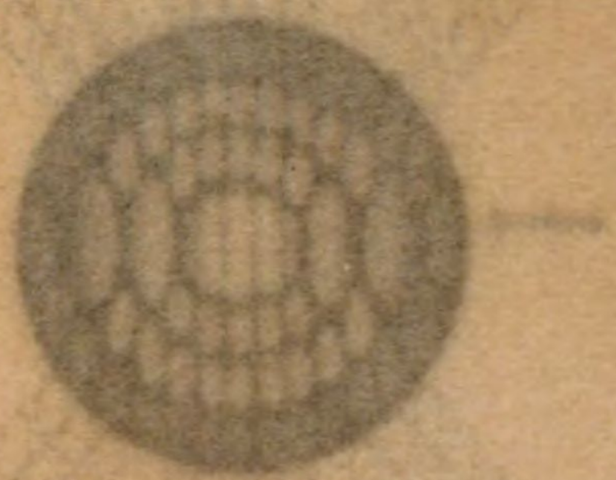

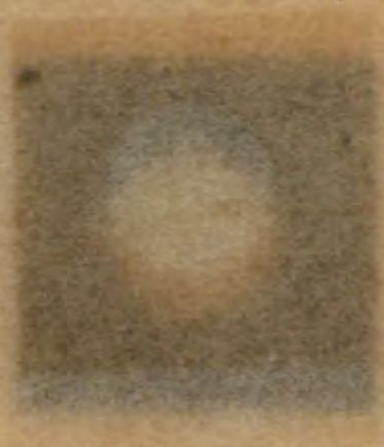

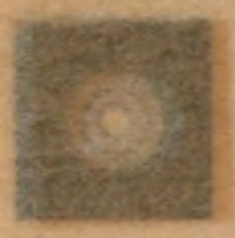

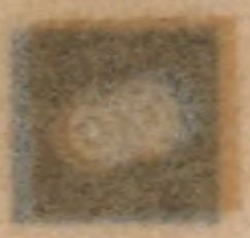

Fig. 17.

Fig. 18.

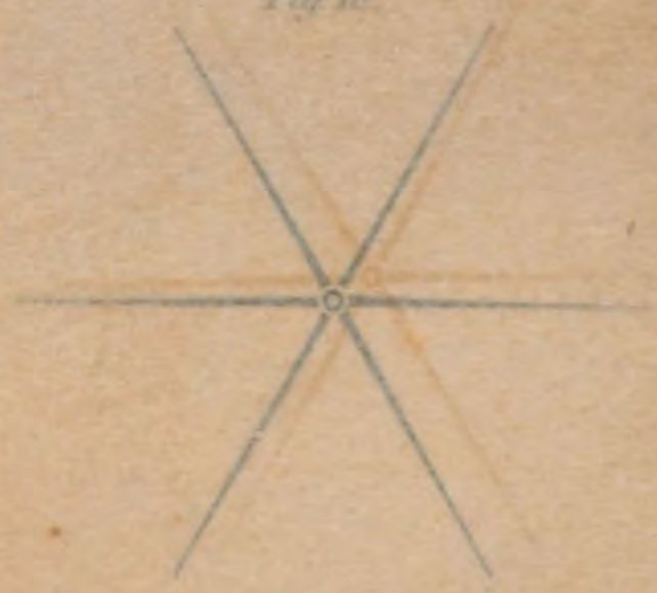

Fig. 19.

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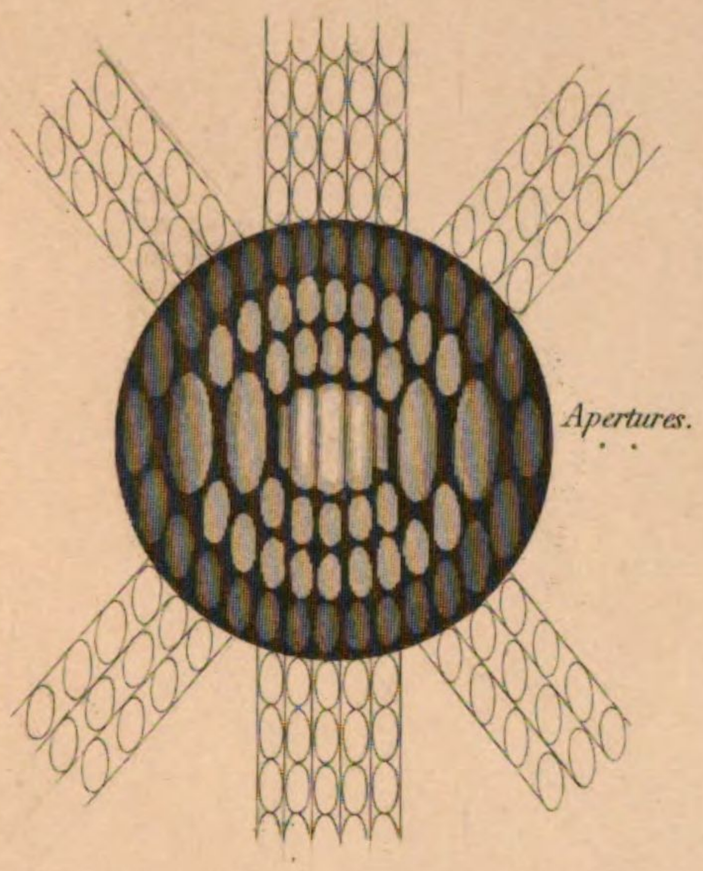

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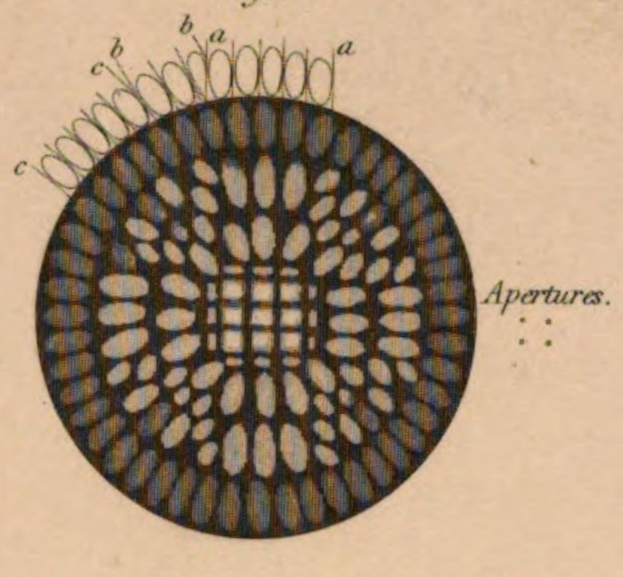

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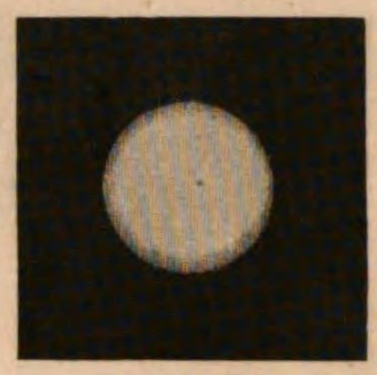

Fig. 12.

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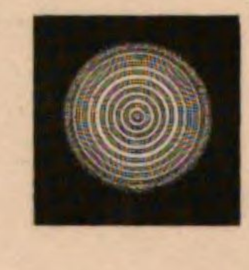
Fig. 15.



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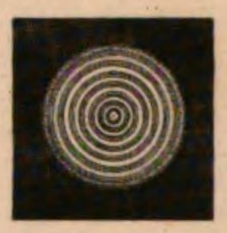

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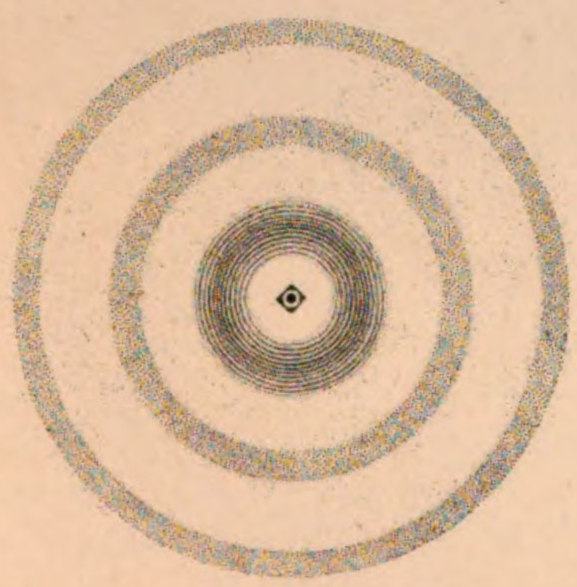

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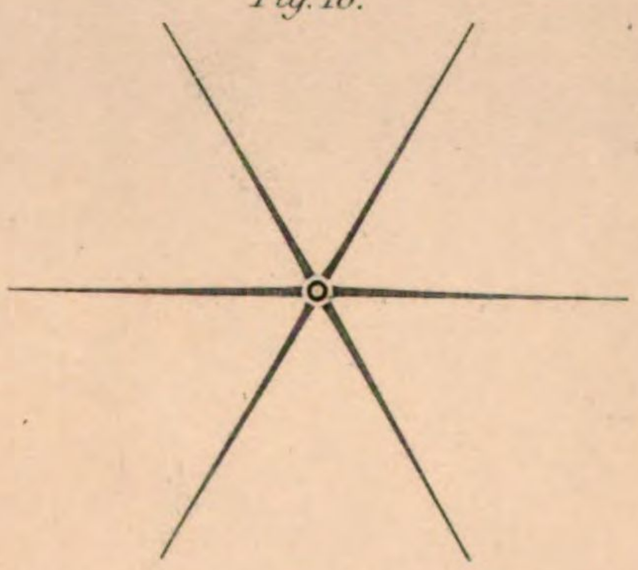

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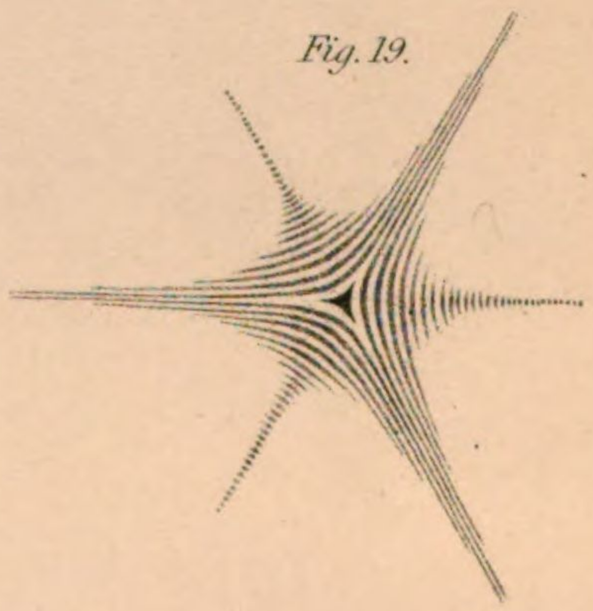

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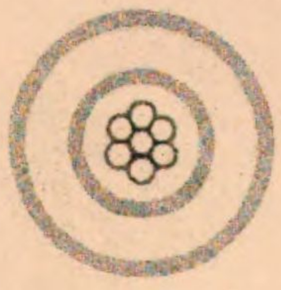

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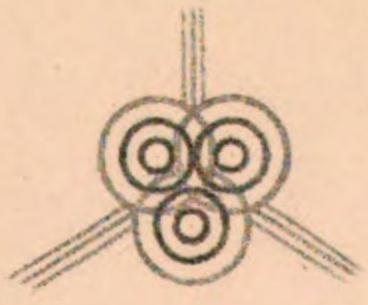

Fig. 22.

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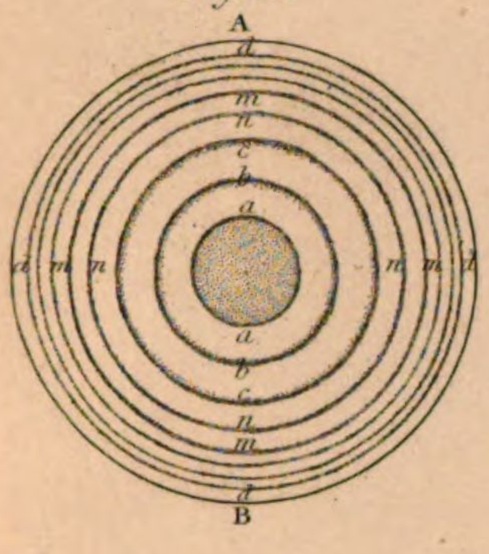
Fig. 23.



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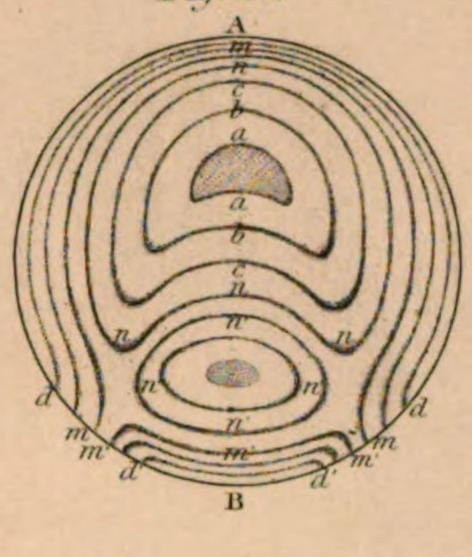

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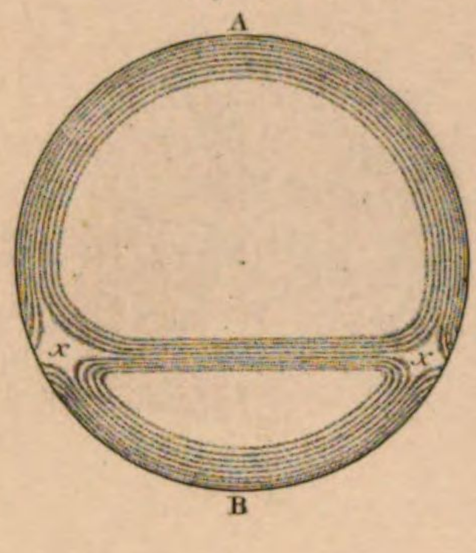

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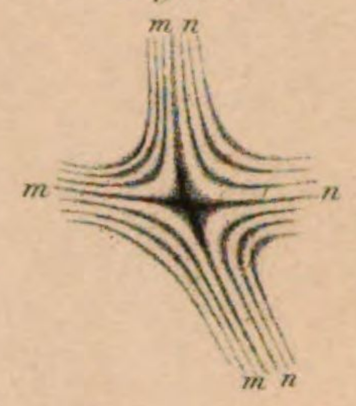

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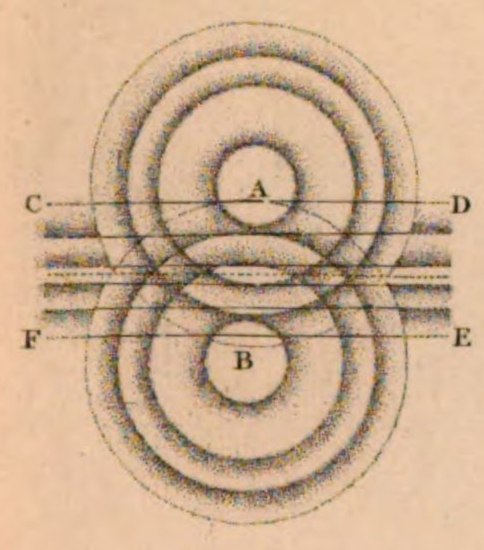

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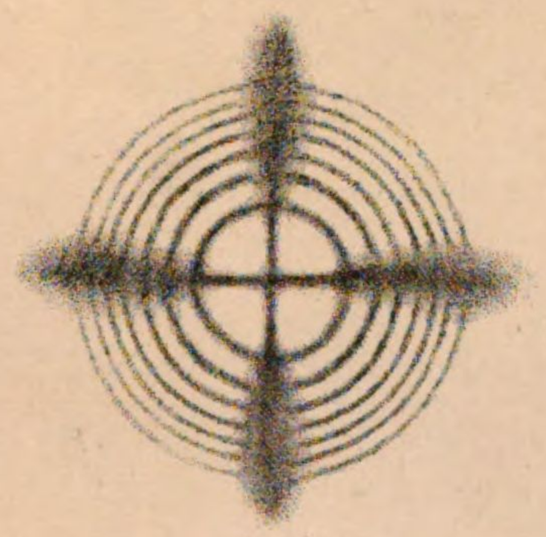

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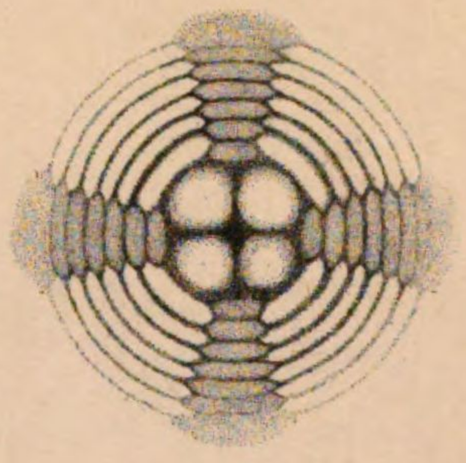

Fig. 31.

Fig. 28.

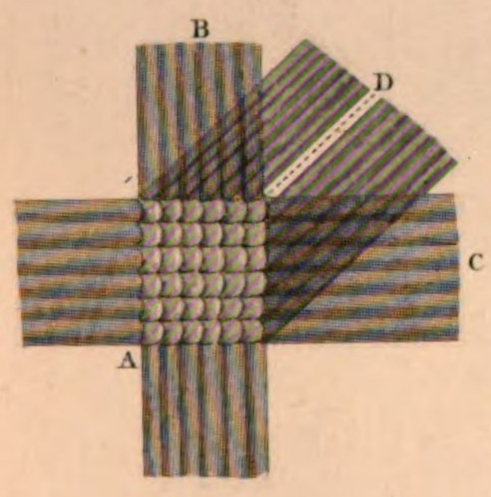

Fig. 32.

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Fig. 34.

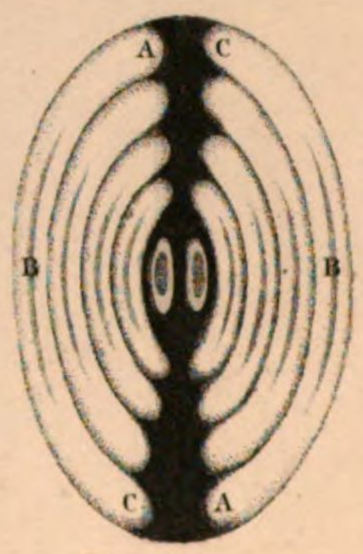
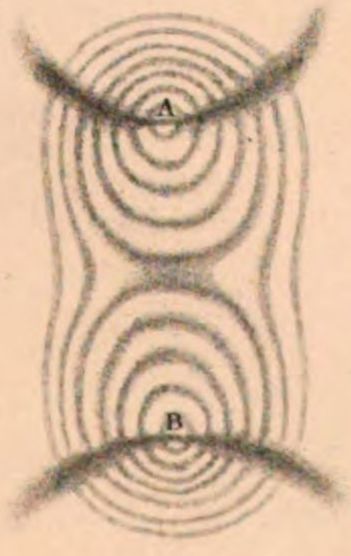


Fig. 35.

Fig. 36.



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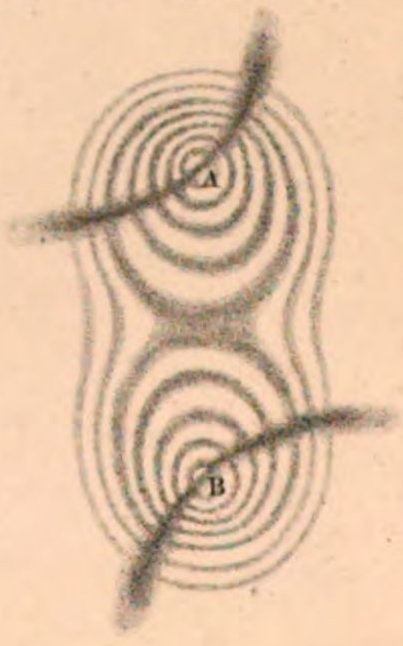

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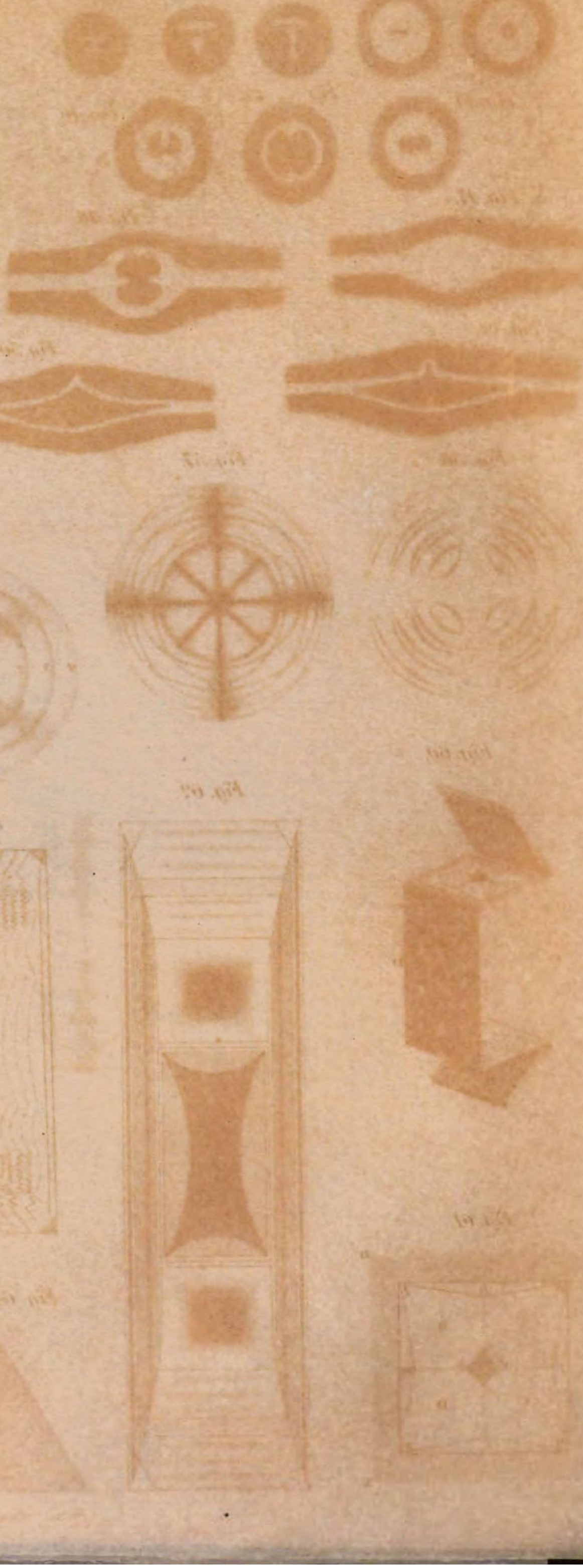

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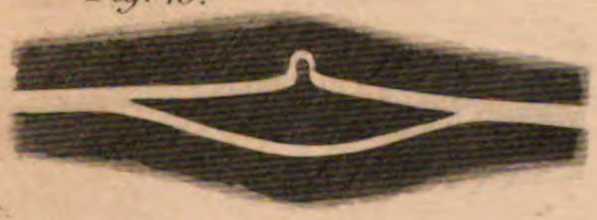

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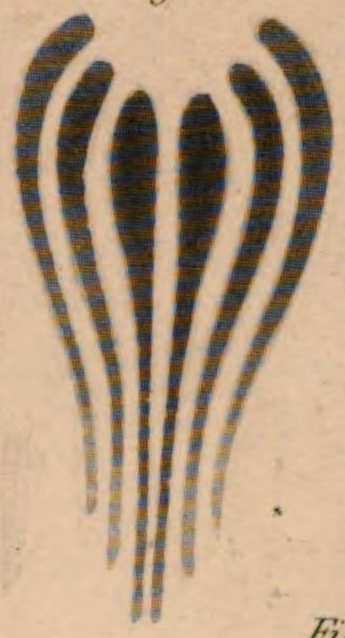
Fig. 51.



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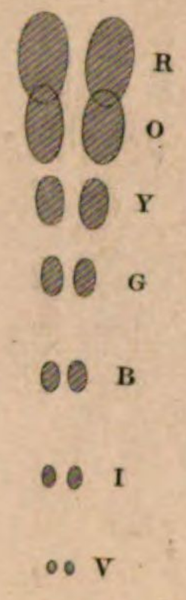

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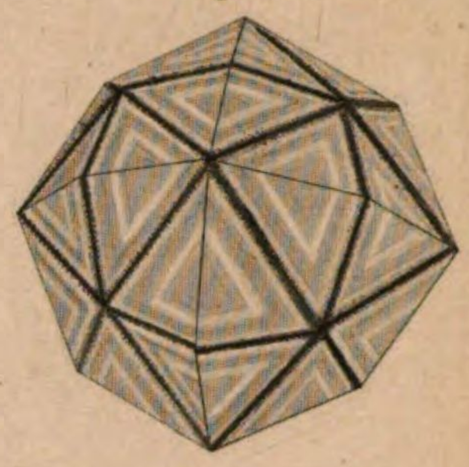

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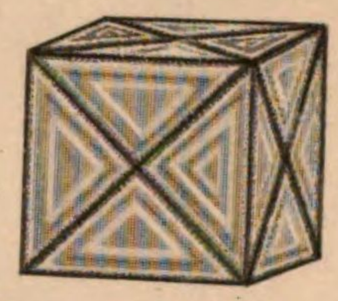

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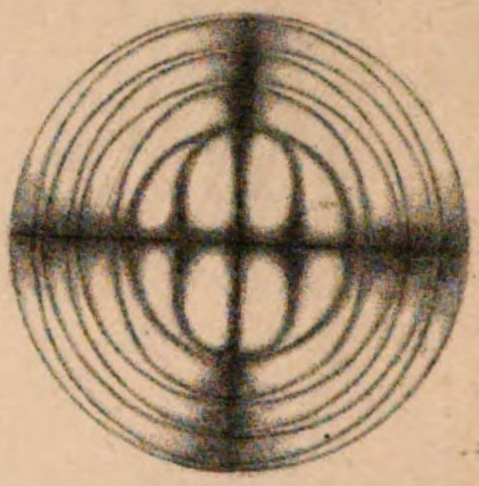

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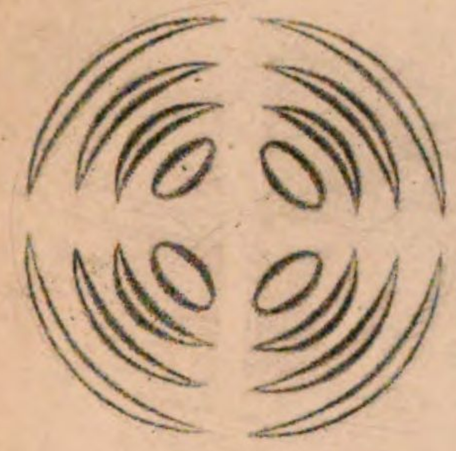

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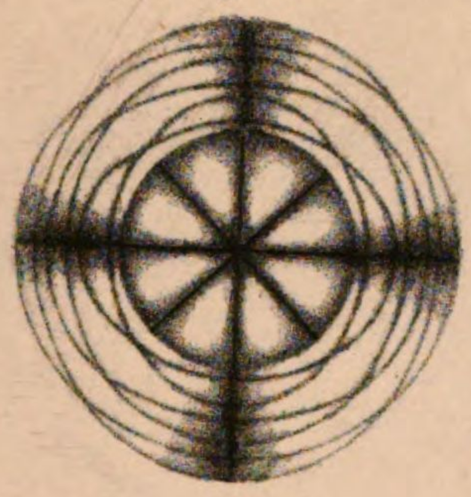

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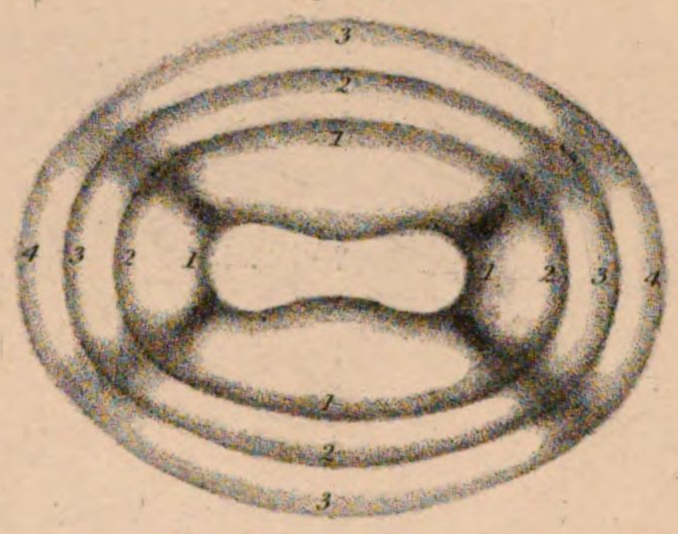

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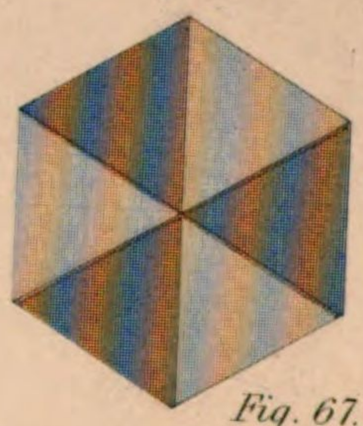

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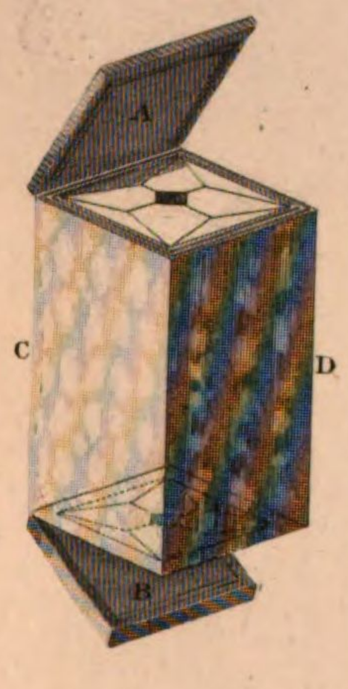

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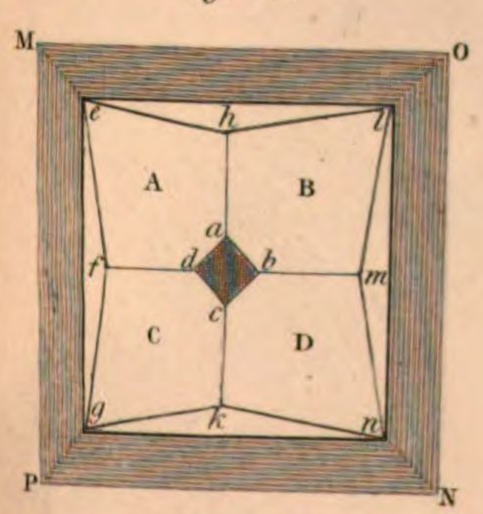

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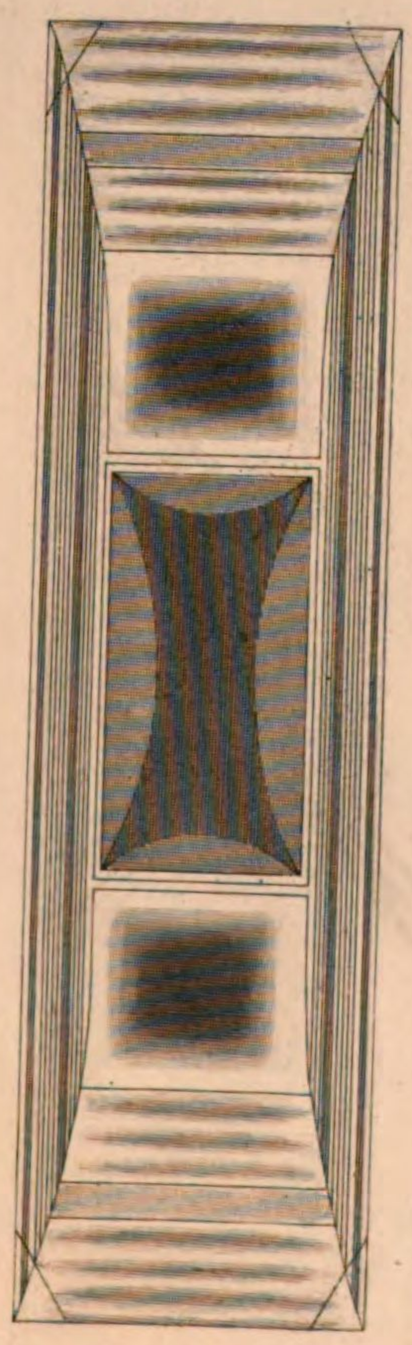

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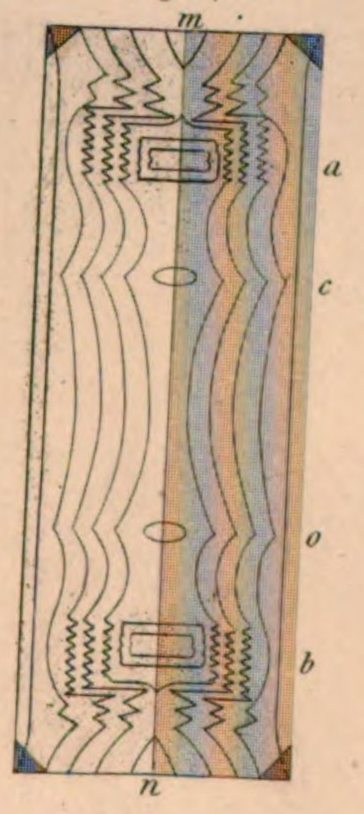

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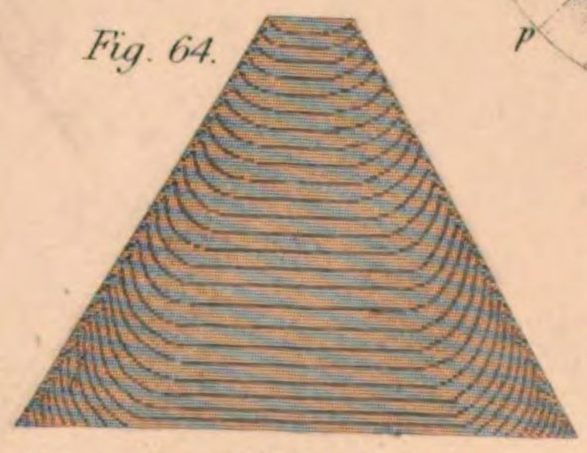

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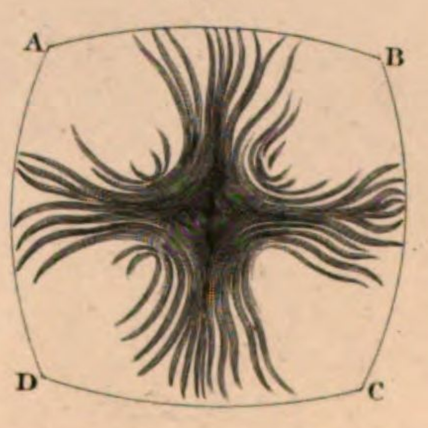

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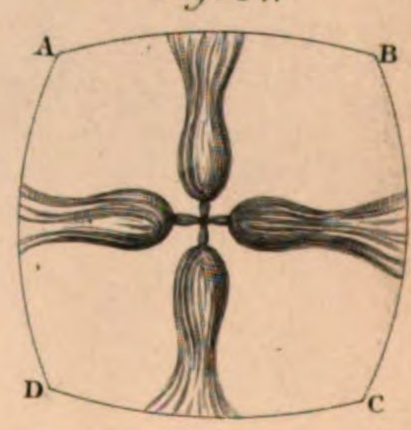
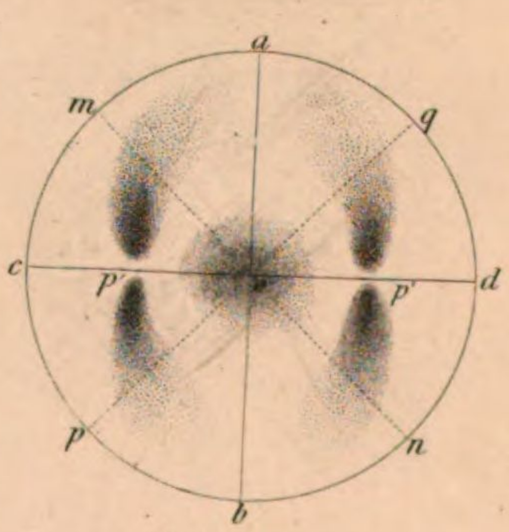


Fig. 67. twice. p. 495.



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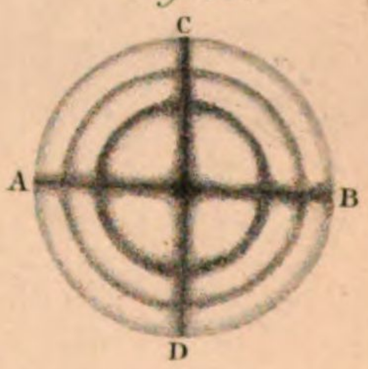

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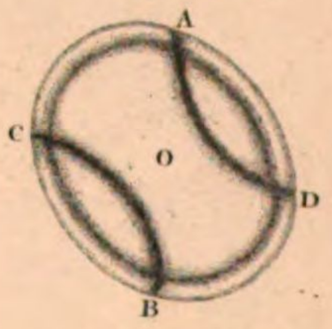

Fringes through the pyramid of Apophyllite

Geo. Aikman, Sculp.

Fig. 90.

Fig. 91.

Fig. 96.

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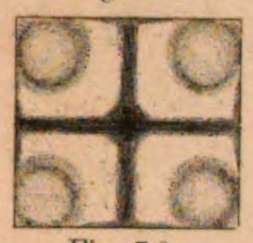
Fig. 103.

Geo. Aikman, Sc.

Fig. 71.



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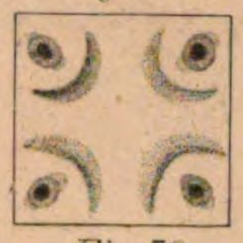

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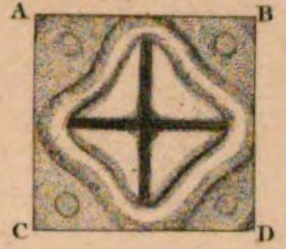


Fig. 74.

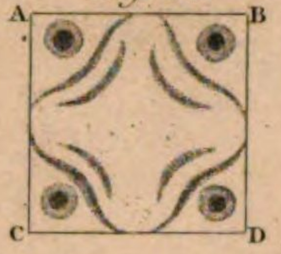
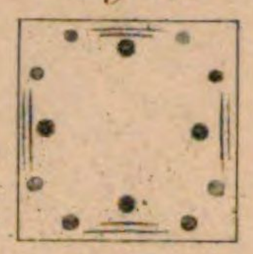


Fig. 75.

Fig. 76.



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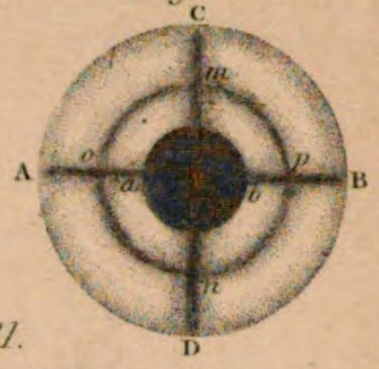

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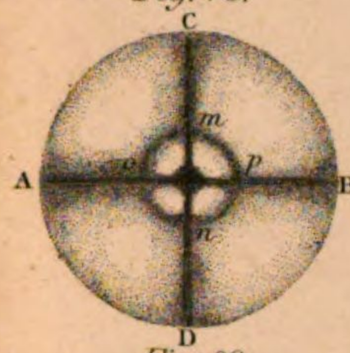

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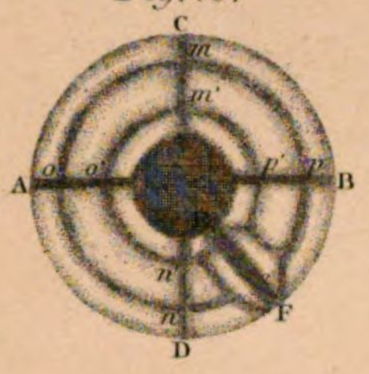

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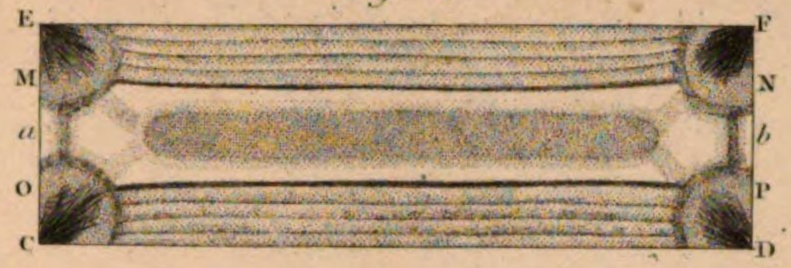

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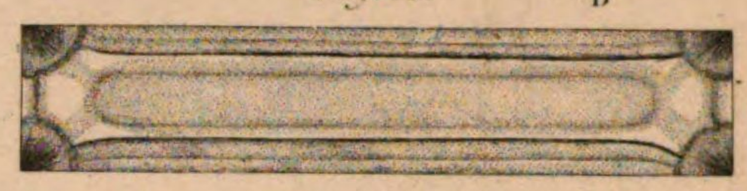
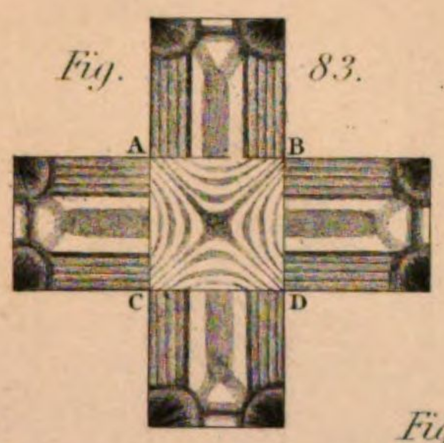


Fig. 82.

Fig. 83.



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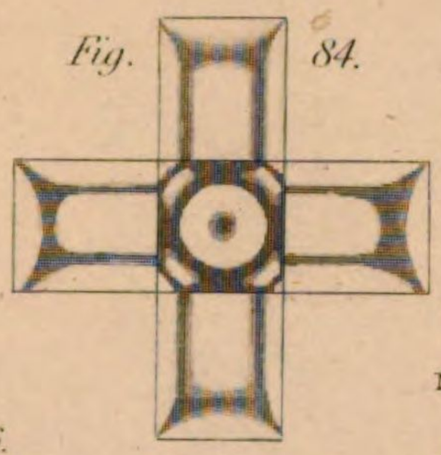

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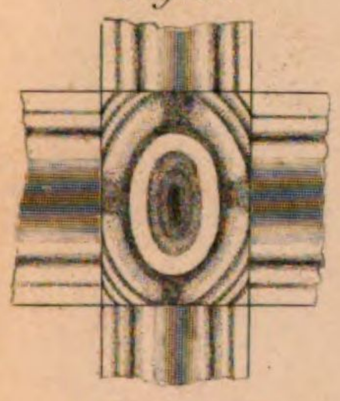

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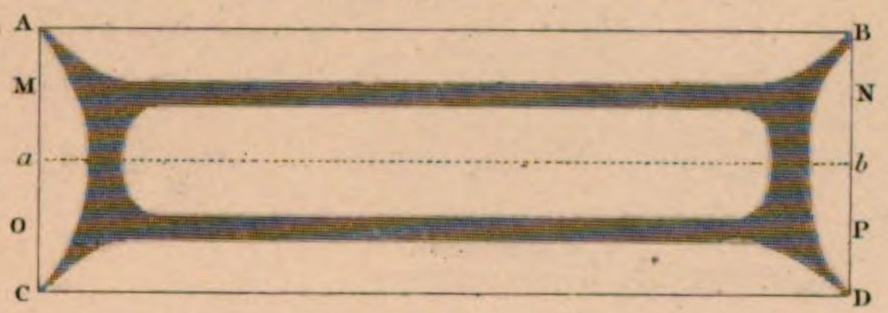
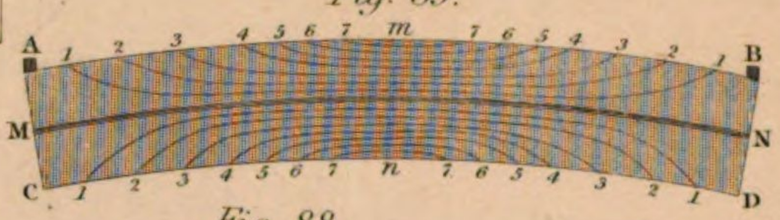


Fig. 87.

Fig. 88.



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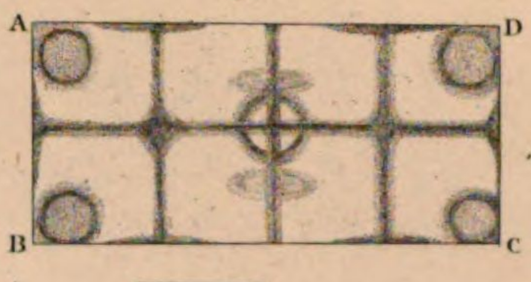
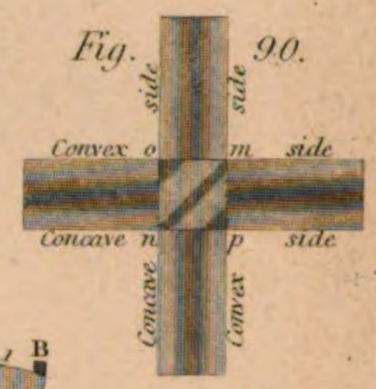


Fig. 90.



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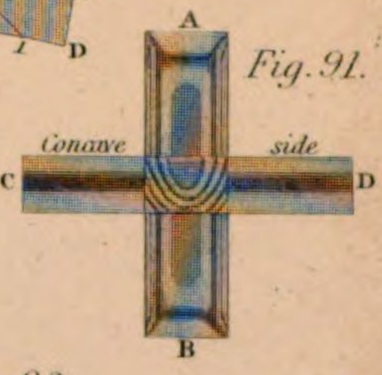

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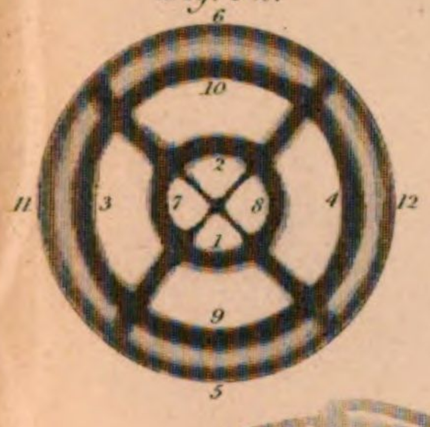

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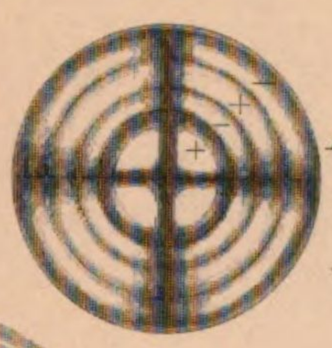

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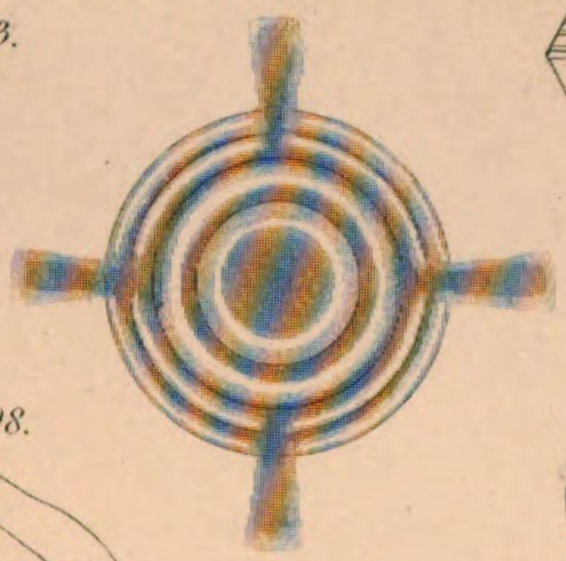

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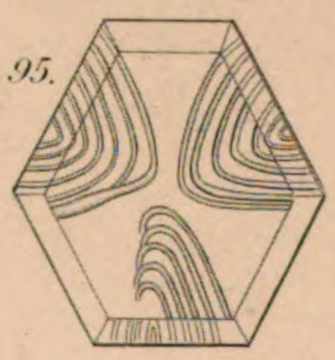


Fig. 96.

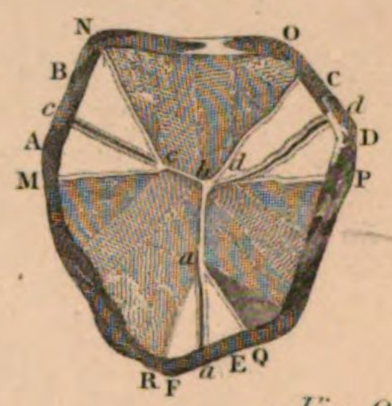
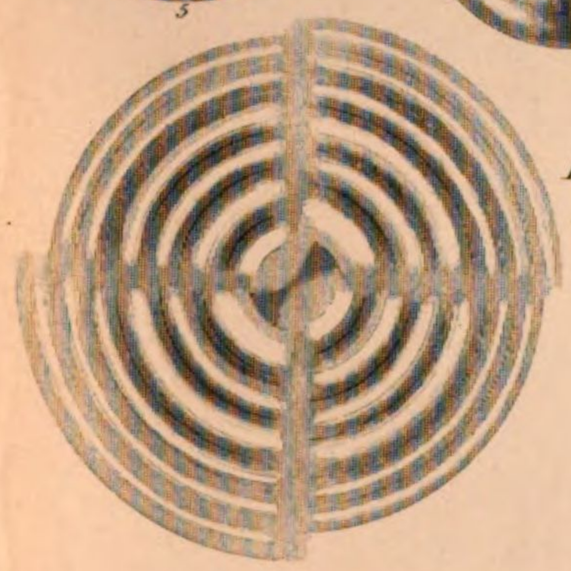


Fig. 97.



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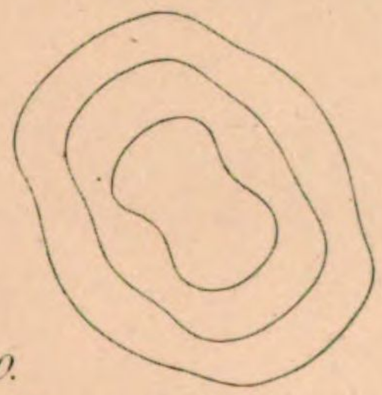

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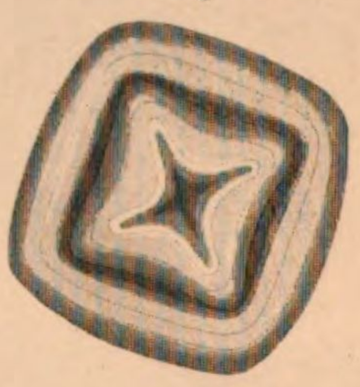

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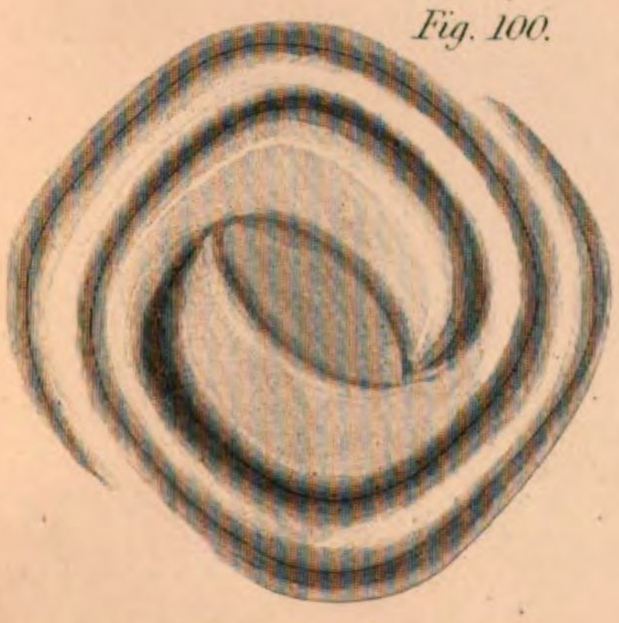

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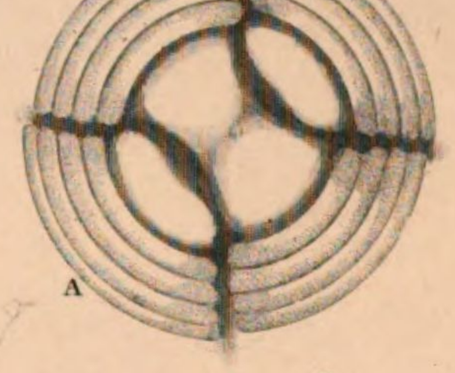

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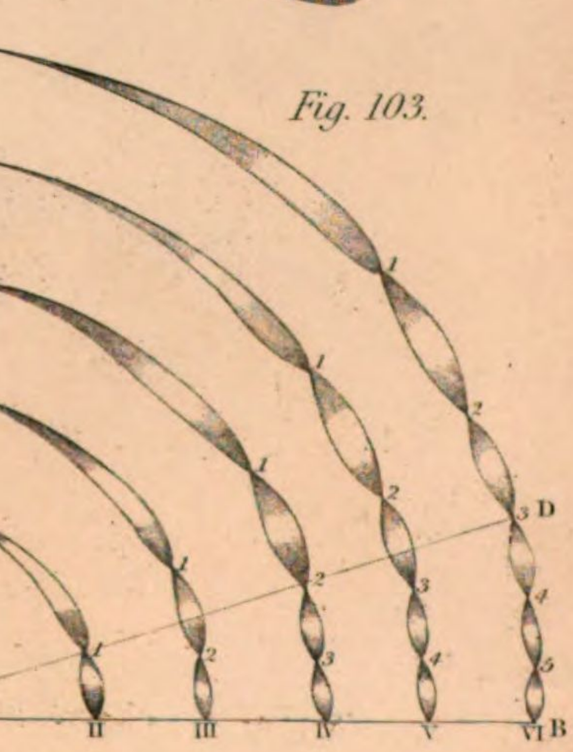


Fig. 103.

Geo. Aikman, Scul.

Fig 101

Fig 102

Fig 103

Fig 104

Fig 105

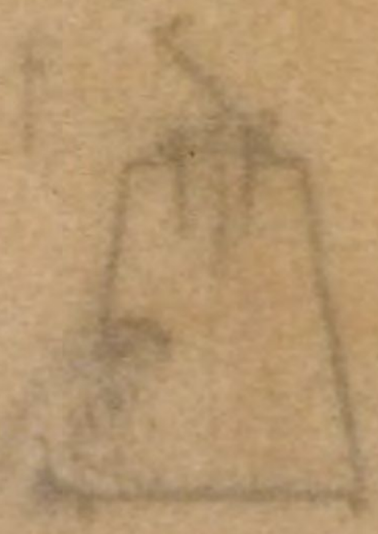


Fig 106

MAGIC LANTERN

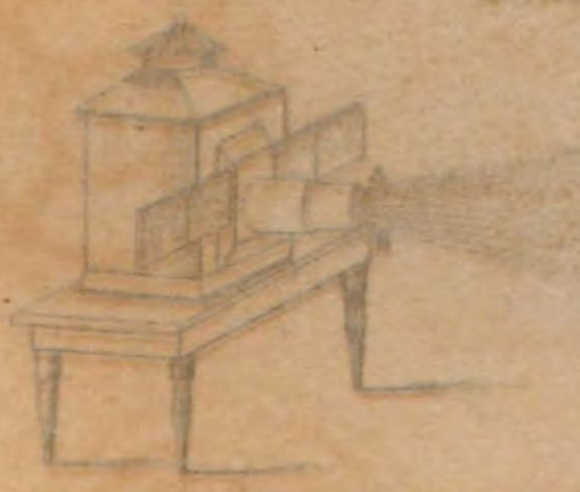


Fig 107

MAGIC LANTERN SLIDES

Fig 108

PHANTASMAGORIC APPARATUS

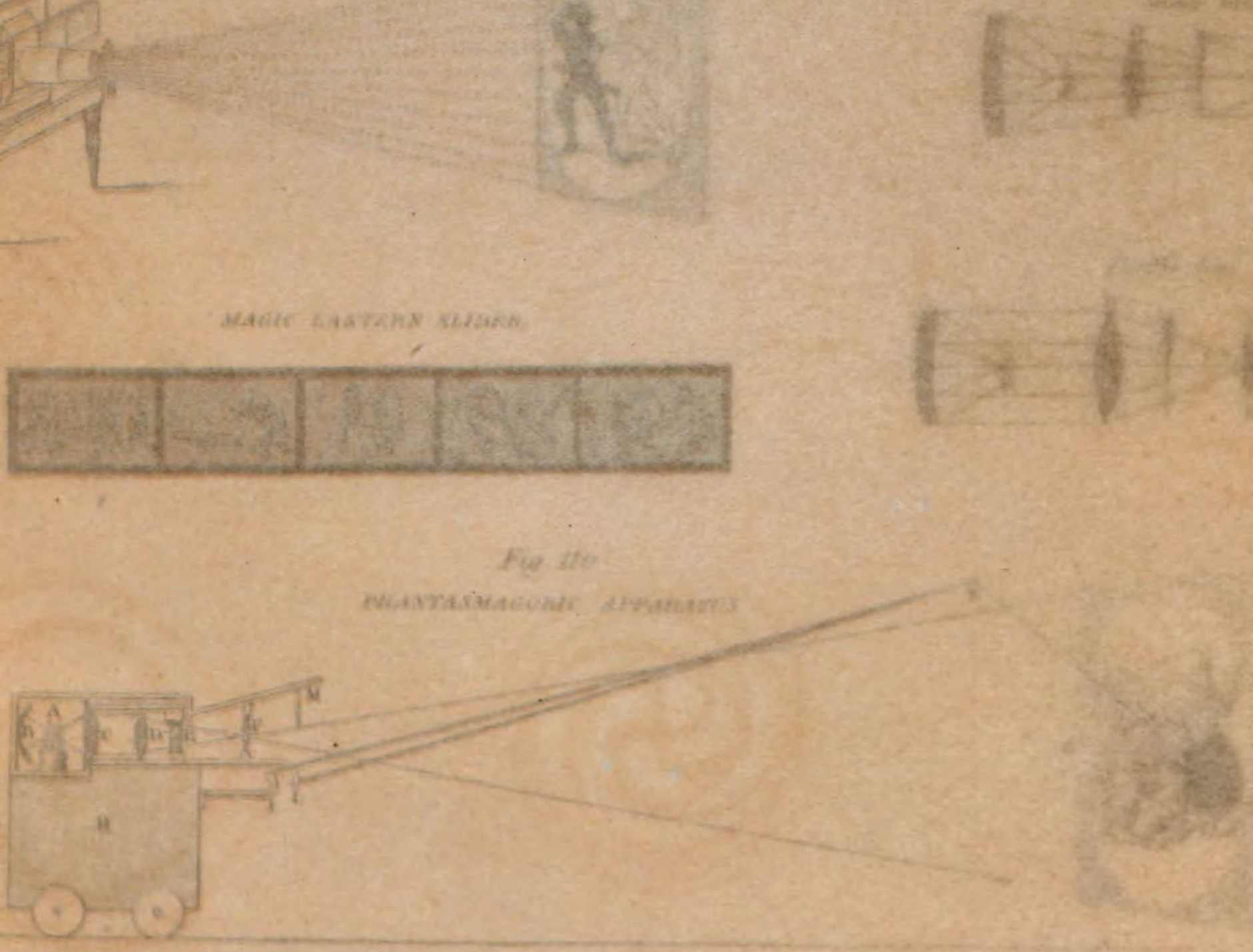


Fig 109

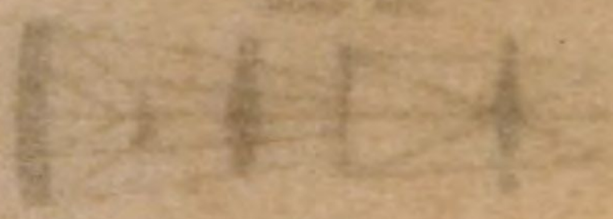
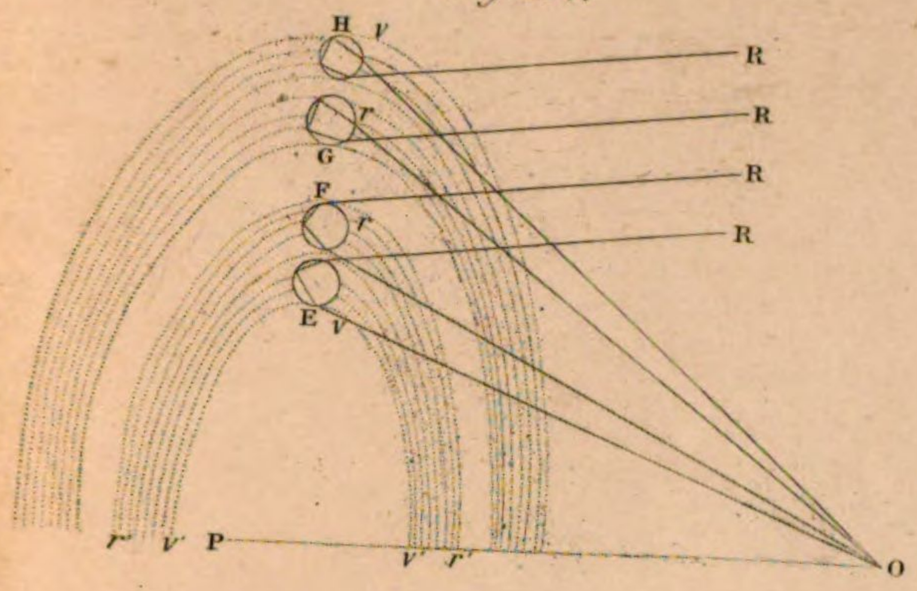


Fig 110

OPTICS.

PLATE CCCLXXXVI.

Fig. 104.



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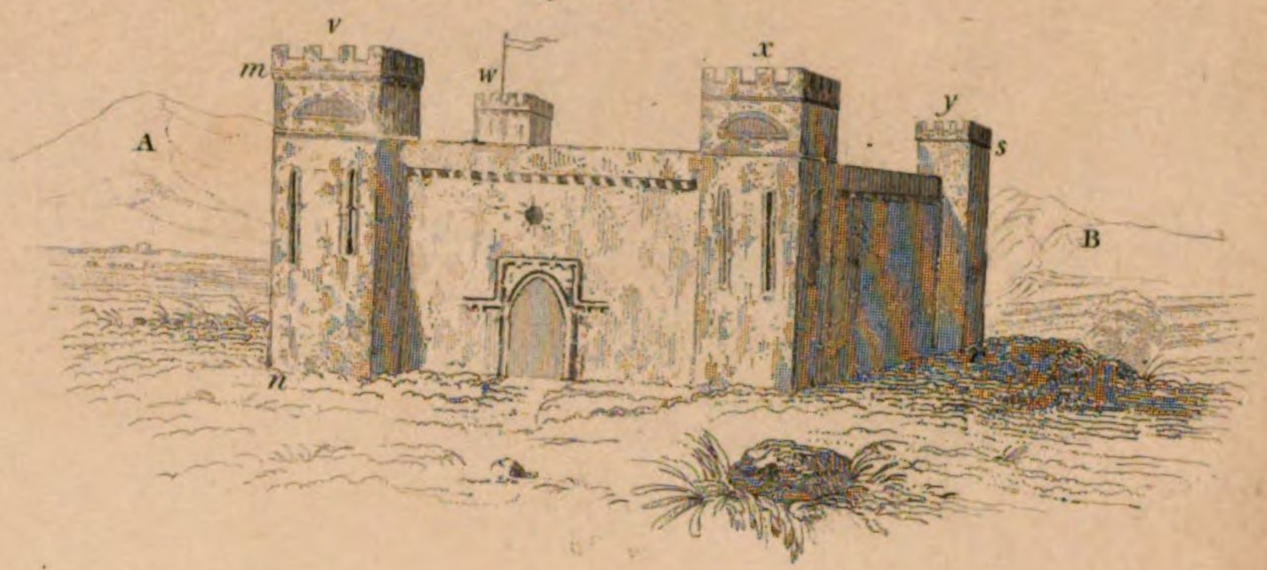
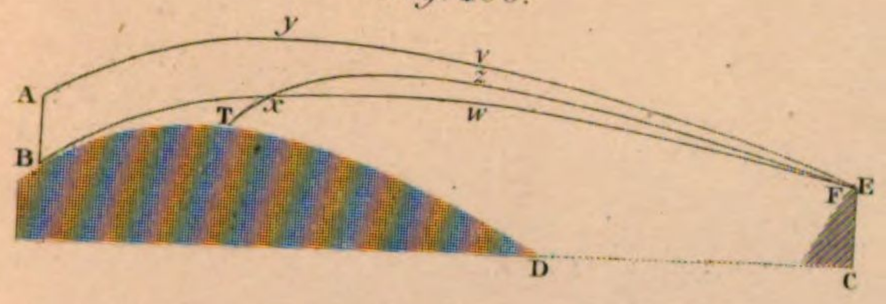


Fig. 106.



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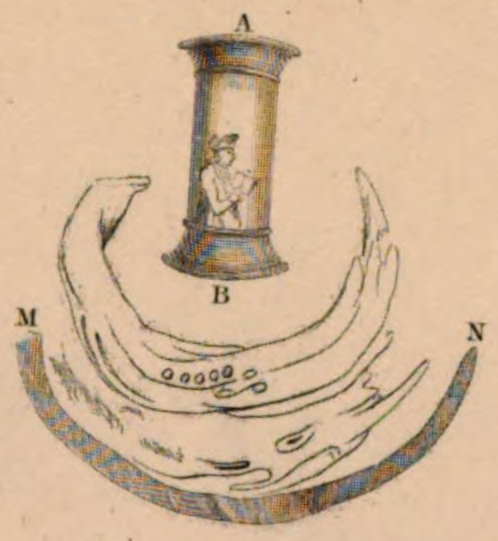


Fig. 108.

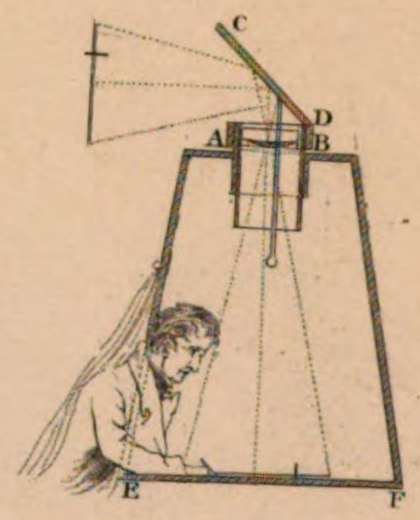
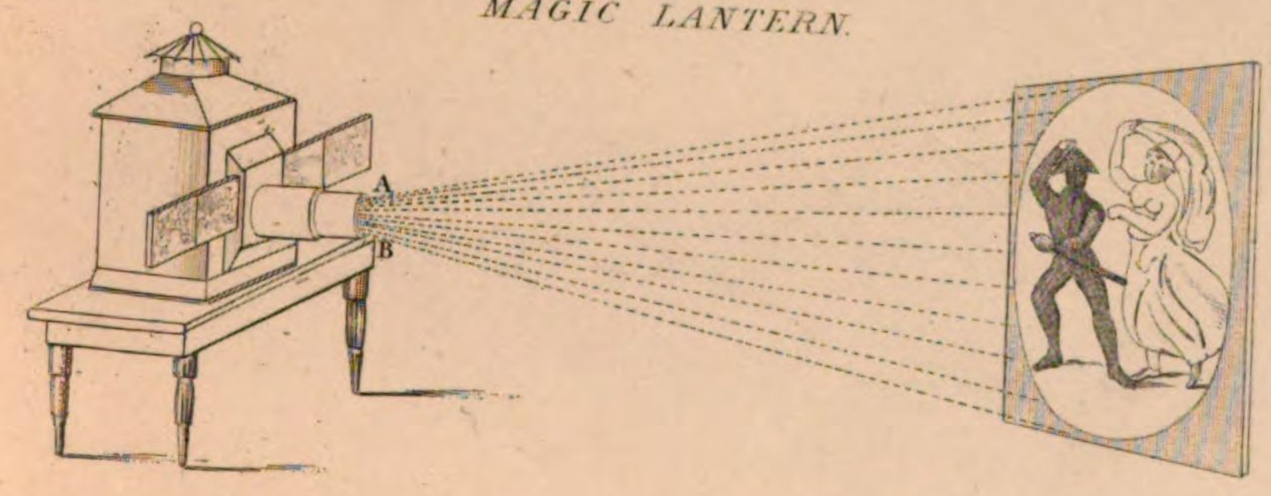


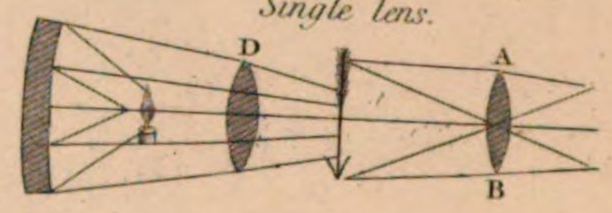
Fig. 109.

MAGIC LANTERN.

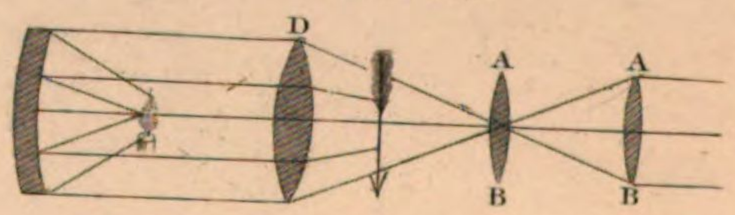


MAGIC LANTERN LENSES.

Single lens.



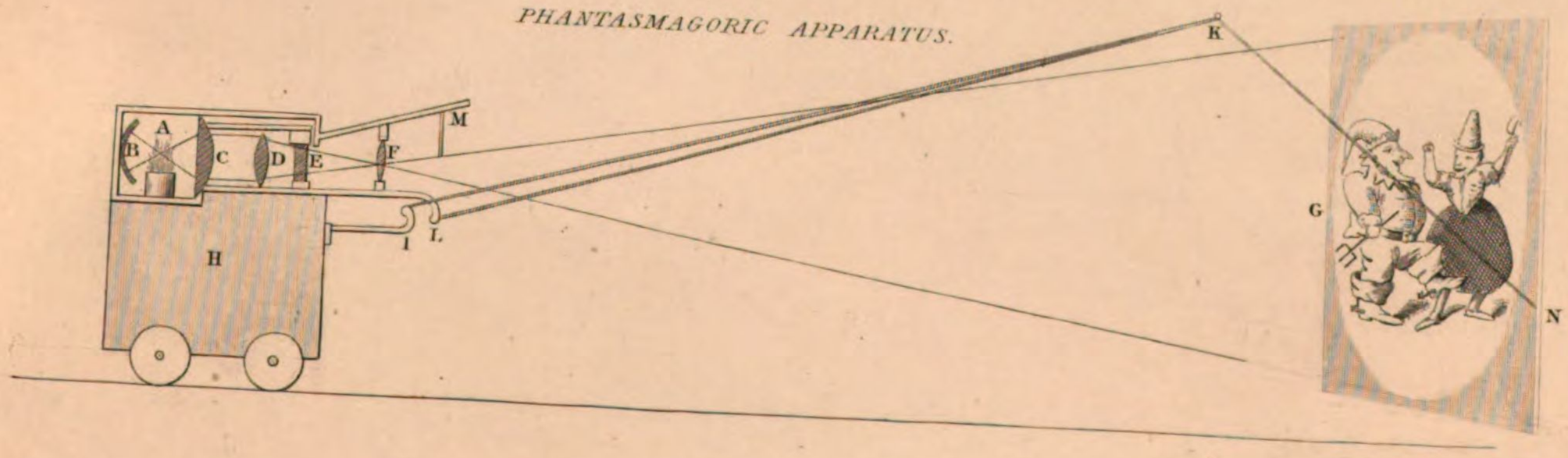
Double lens.



MAGIC LANTERN SLIDER.

Fig. 110.

PHANTASMAGORIC APPARATUS.

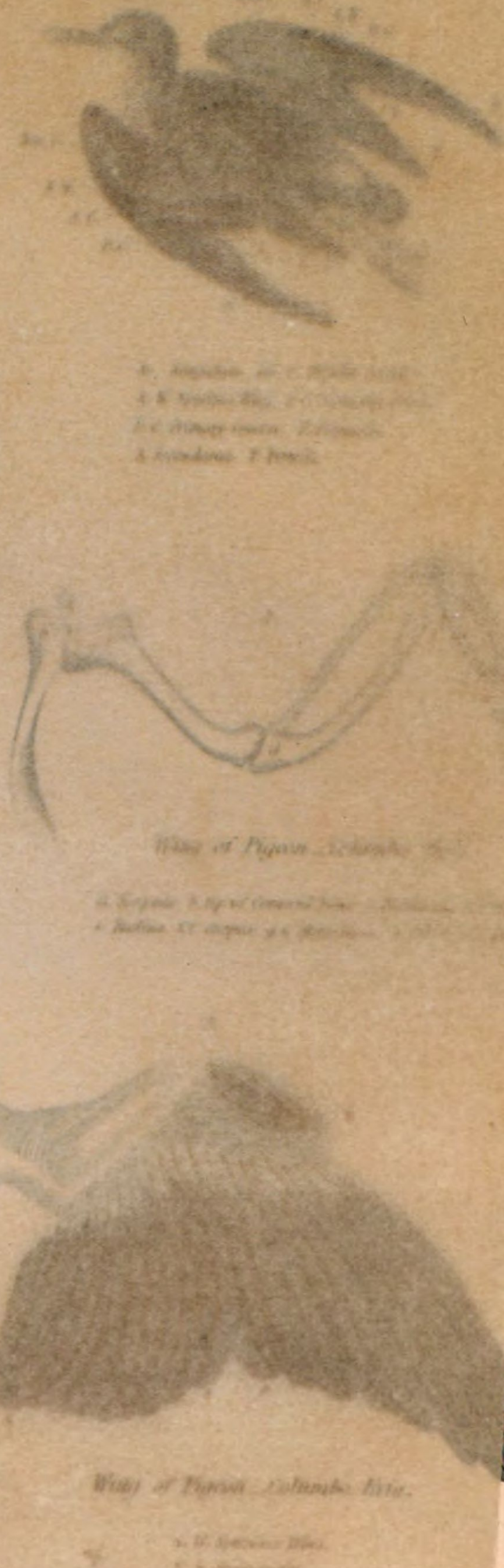


Geo. Aikman, Sculp.

a. Scapula. b. Coracoid bone or Clavicle. c.c. Humerus. d.d. Ulna. e.e. Radius. f. Carpus. g.g. Metacarpus. h. Pollex. i.i. Digits.

k. Femur or thigh bone. l.l. Tibiæ or Gambs. m. m. Tibia or leg bone. n.n. Tarsus. o. small Metatarsal bone. 1.2.3.4. Toes.

Skeleton of Golden Eagle. Aquila chrysaetus.



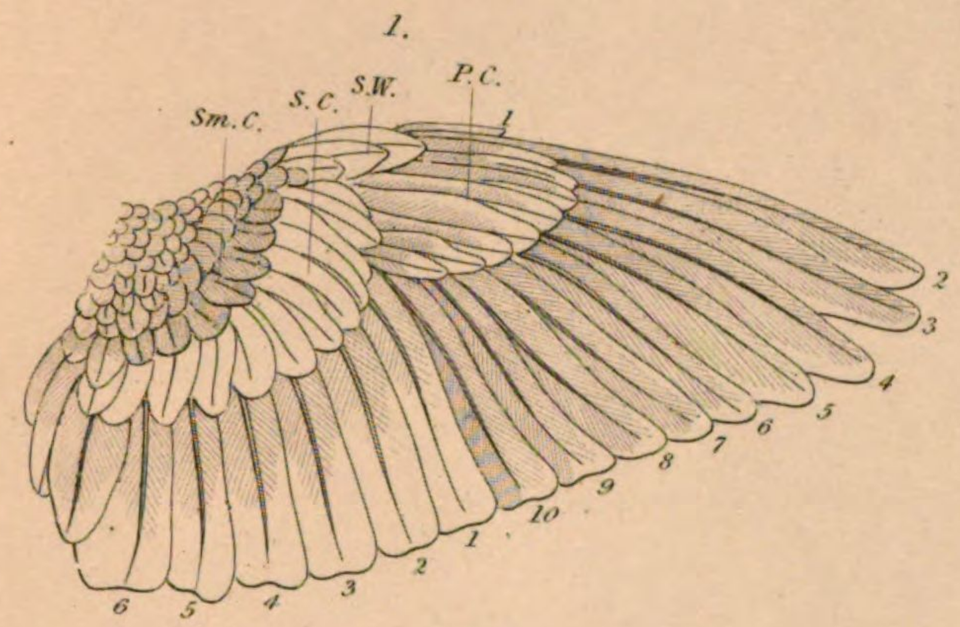
Wing of Pigeon. Columba livia.

Wing of Pigeon. Columba livia.

P.

W. Aikman, Sc.

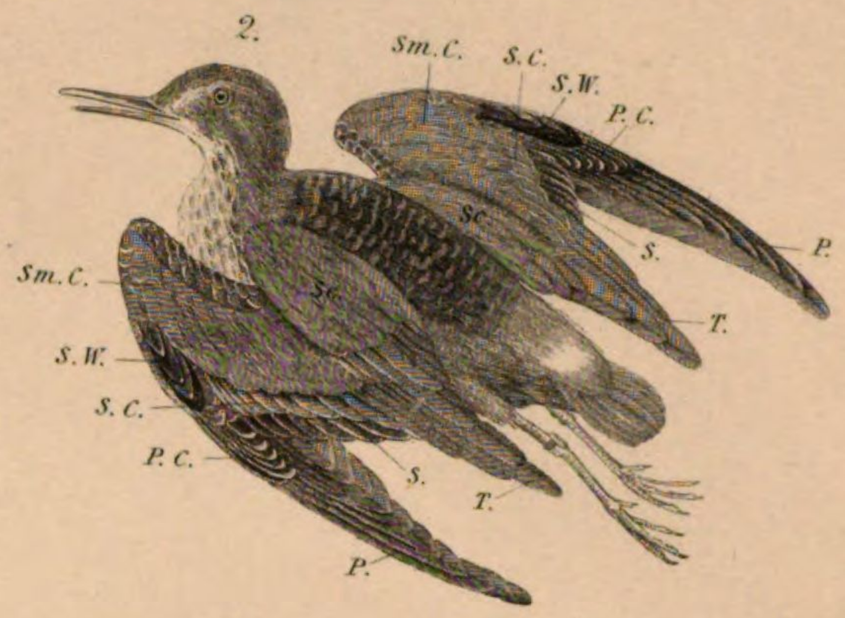
1.



Wing of Starling_Sturnus vulgaris.

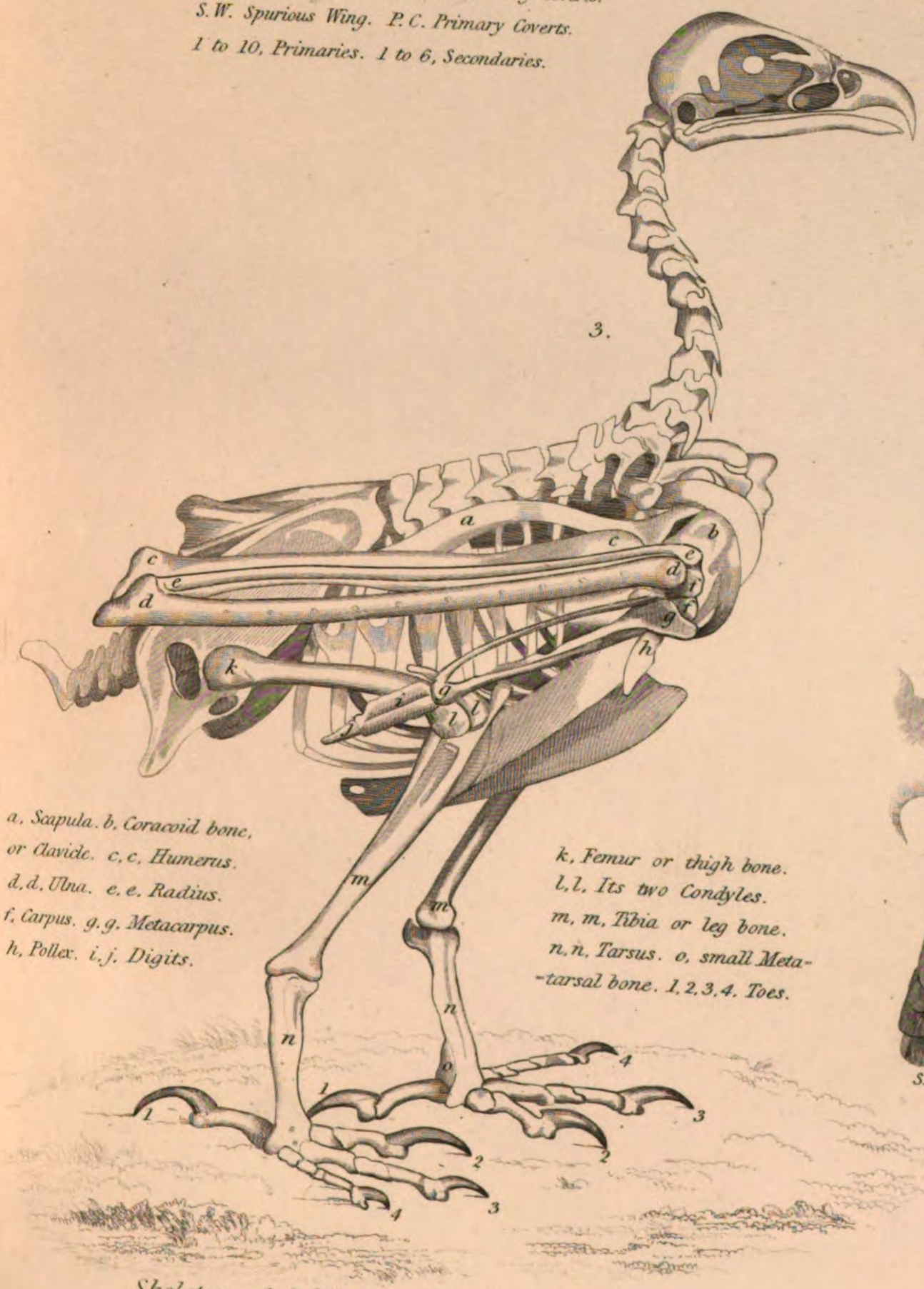
Sm.C. Smaller Coverts. S.C. Secondary Coverts.
S.W. Spurious Wing. P.C. Primary Coverts.
1 to 10, Primaries. 1 to 6, Secondaries.

2.



Sc. Scapulars. Sm. C. Smaller Coverts.
S. W. Spurious Wing. S.C. Secondary Coverts.
P. C. Primary Coverts. P. Primaries.
S. Secondaries. T. Tertials.

3.

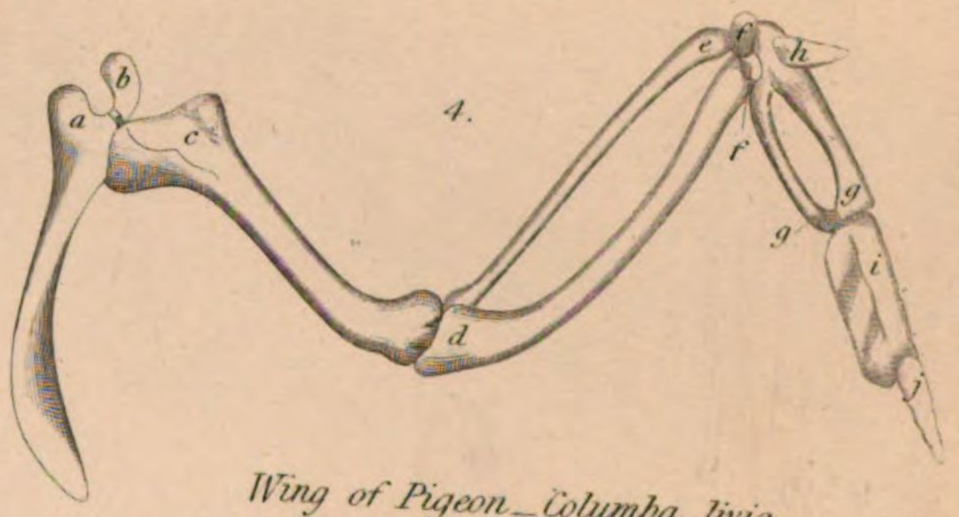


a, Scapula. b, Coracoid bone,
or Clavicle. c, c, Humerus.
d, d, Ulna. e. e. Radius.
f, Carpus. g. g. Metacarpus.
h, Pollex. i, j. Digits.

k, Femur or thigh bone.
l, l, Its two Condyles.
m, m, Tibia or leg bone.
n, n, Tarsus. o, small Meta-
-tarsal bone. 1, 2, 3, 4. Toes.

Skeleton of Golden Eagle_Aquila chrysaetus.

4.



Wing of Pigeon_Columba livia.

a. Scapula. b, tip of Coracoid bone. c, Humerus. d, Ulna.
e, Radius. f, f. Carpus. g, g. Metacarpus. h, Pollex. i, j. Digits.

5.

Wing of Pigeon_Columba livia.

S. W. Spurious Wing.
S. S. Secondaries.
P. P. Primaries.

Drawn by W. Macgillivray.

Geo. Aikman, Sculpt.

Vultur cinereus.

Catharista atrata.

Sarcoramphus papa.

Vultur percnopterus.

Gypaetus barbatus.

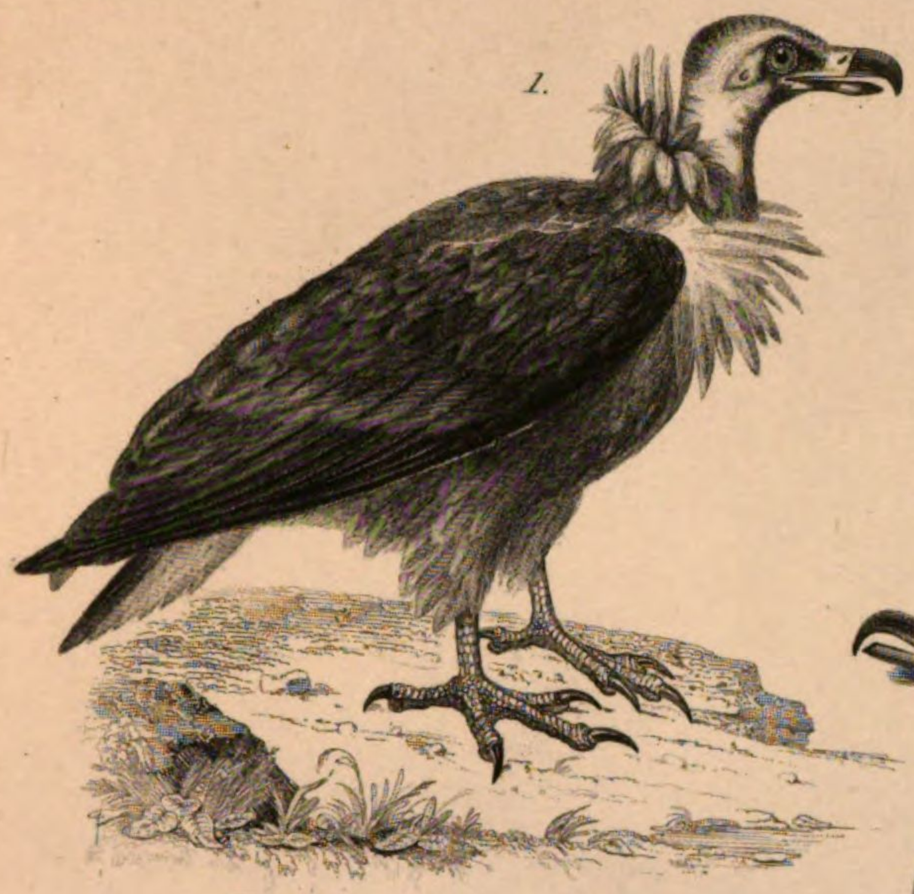
Gymnogyps Californianus.

Harpyia destructor.

Haliaetus albicilla.

Morphnus urubitinga.

1.

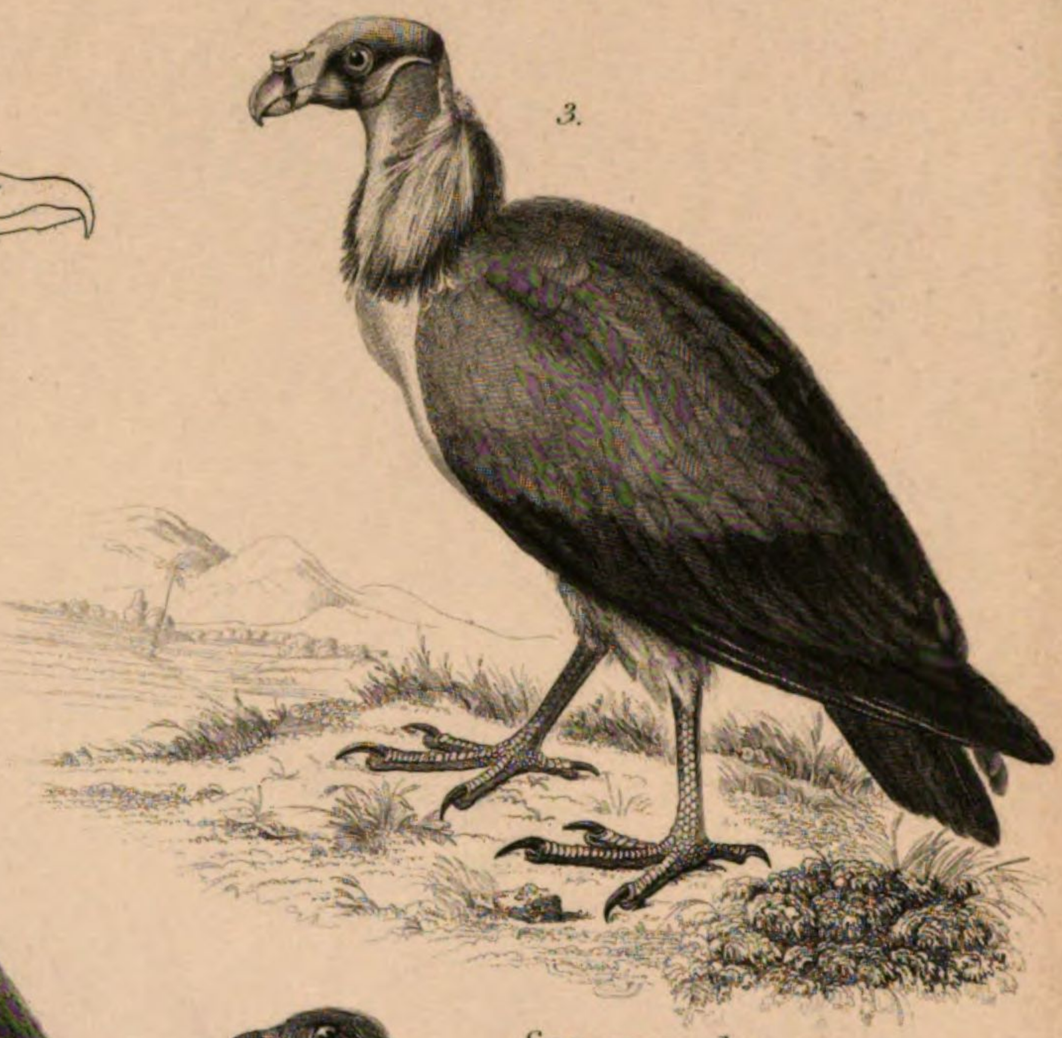


Vultur cinereus.

2.

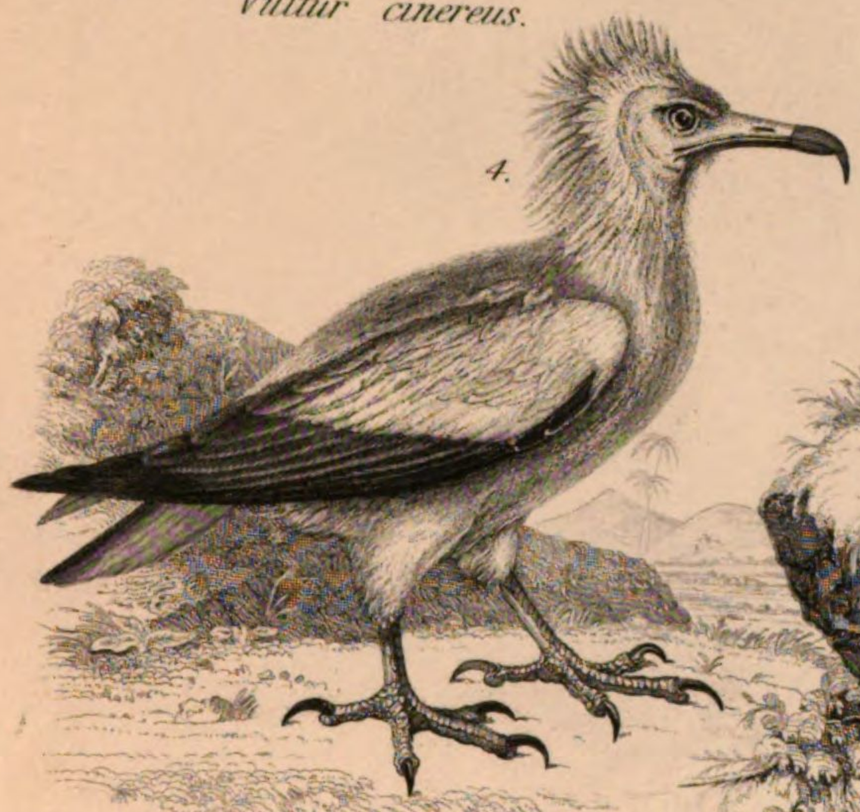
Cathartes aura.

3.



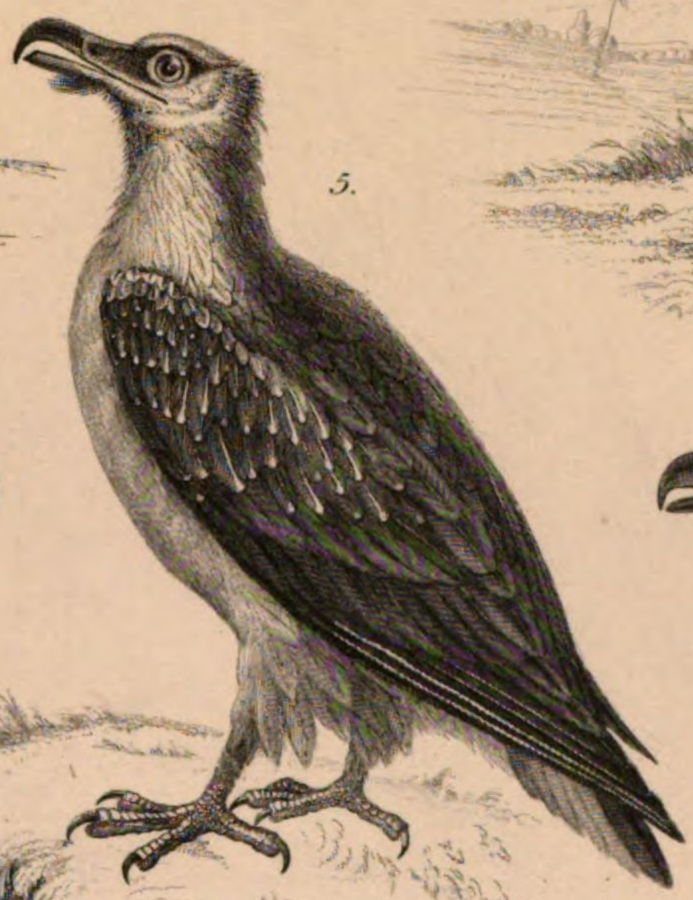
Sarcoramphus papa.

4.



Neophron percnopterus.

5.

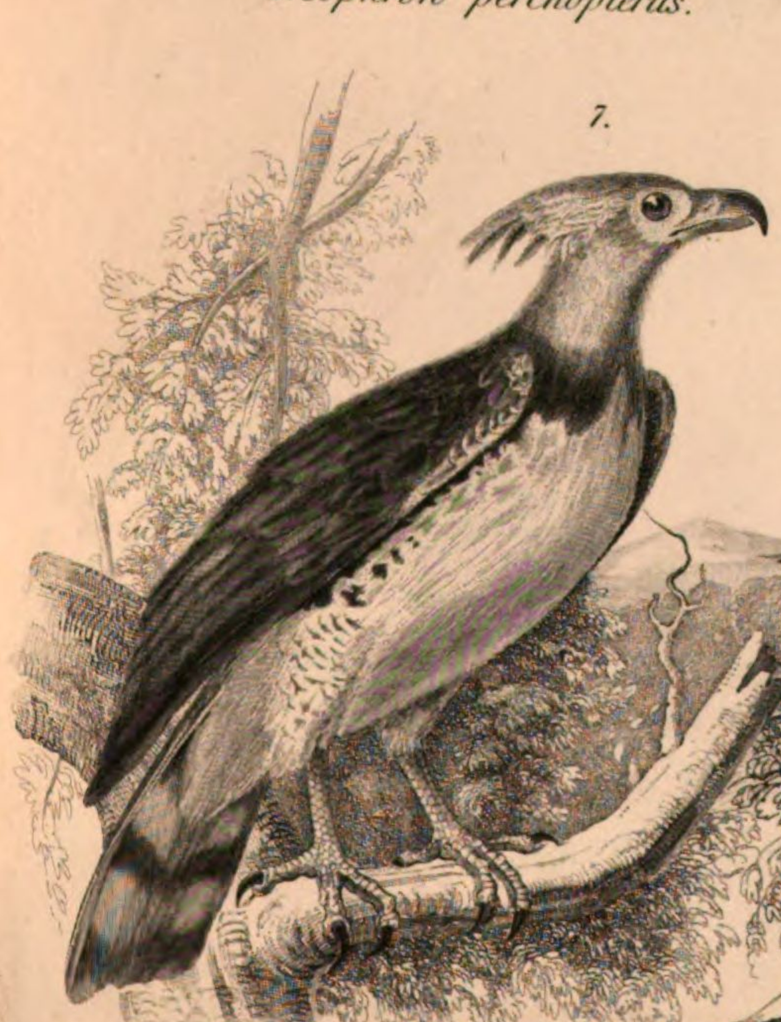


Gypaetus barbatus.

6.

Caracara Braziliensis.

7.



Harpyia destructor.

8.

Haliaetus albicilla.

9.

Morphnus cristatus.

Geo. Aikman, Sculpt.

Milvus furcatus.

Pernis cristata.

3.

Head of Falco.

Falco Islandicus.

Syrnium grapodeum.

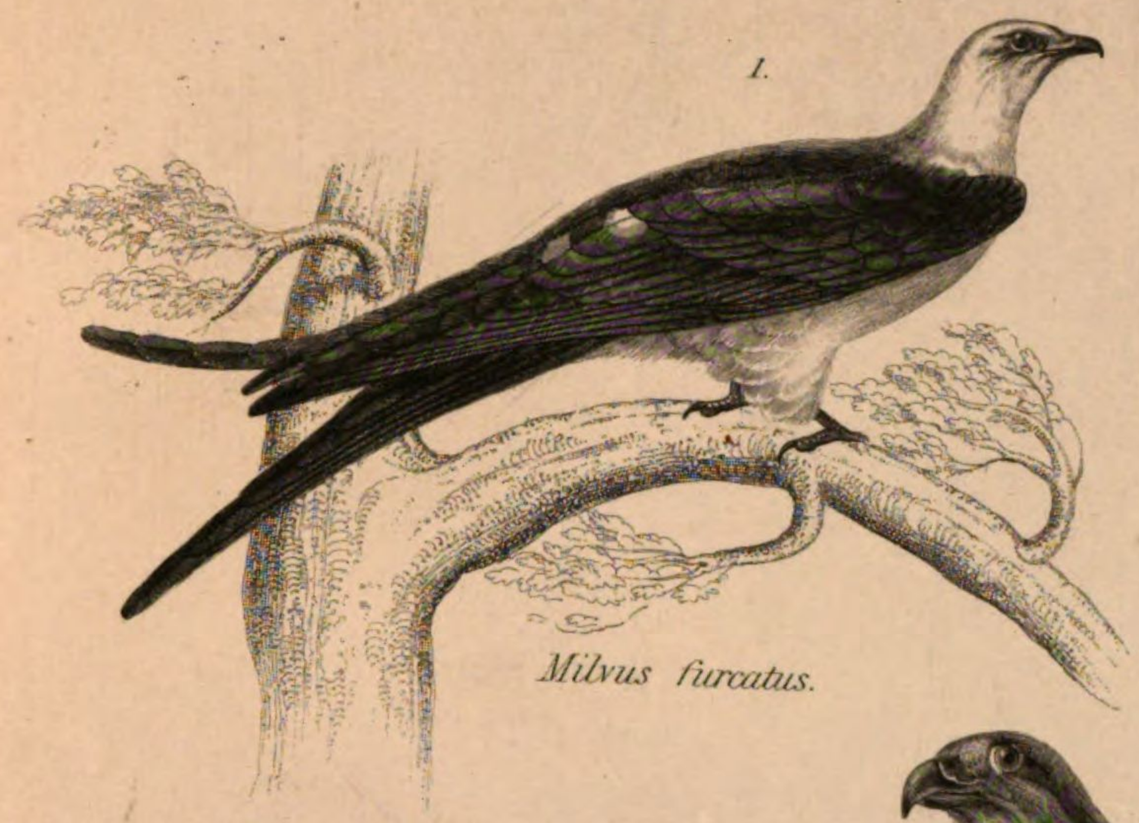
Circus superciliosus.

Strix vulgaris

Bubo Virginianus.

Falco

1.

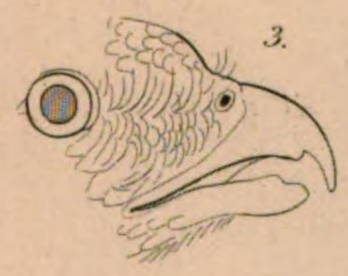


Milvus furcatus.

2.

Pernis cristata.

3.



Head of Falco.

4.

Falco Islandicus.

5.

Circus superciliosus.

6.

Syrnium pagodarum.

7.

Scops vulgaris.

8.

Bubo Virginianus.

9.

Gypogeranus serpentarius.

Geo. Aikman, Sculp.

Lanius collaris.

Beak of Vanga.

Beak of Dulphinus.

Beak of Pomatorhinus.

Head of Cephalopterus.

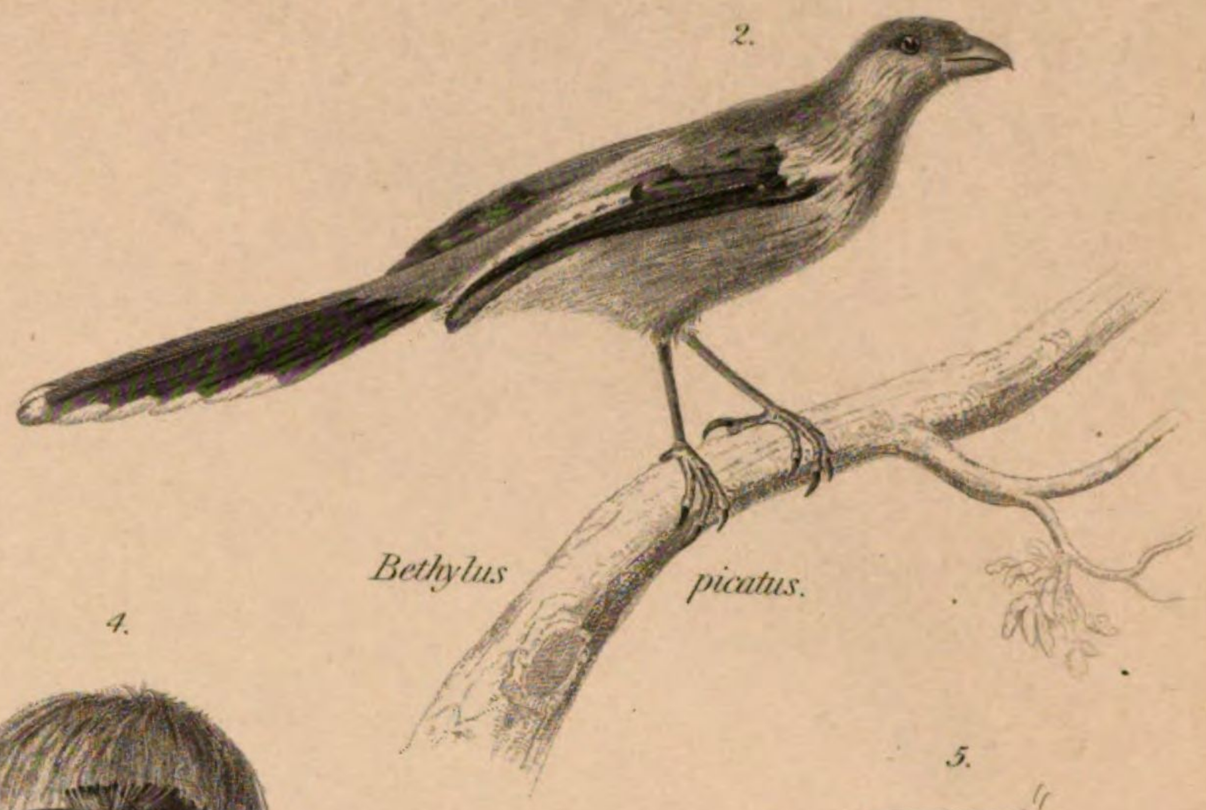
Lepidocolaptes ornatus.

Falcinellus remifer.

1.

Lanius collaris.

2.



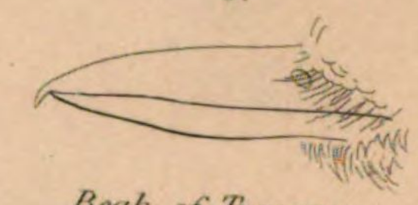
Bethylus picatus.

3.

Beak of Vanga.

4.

5.

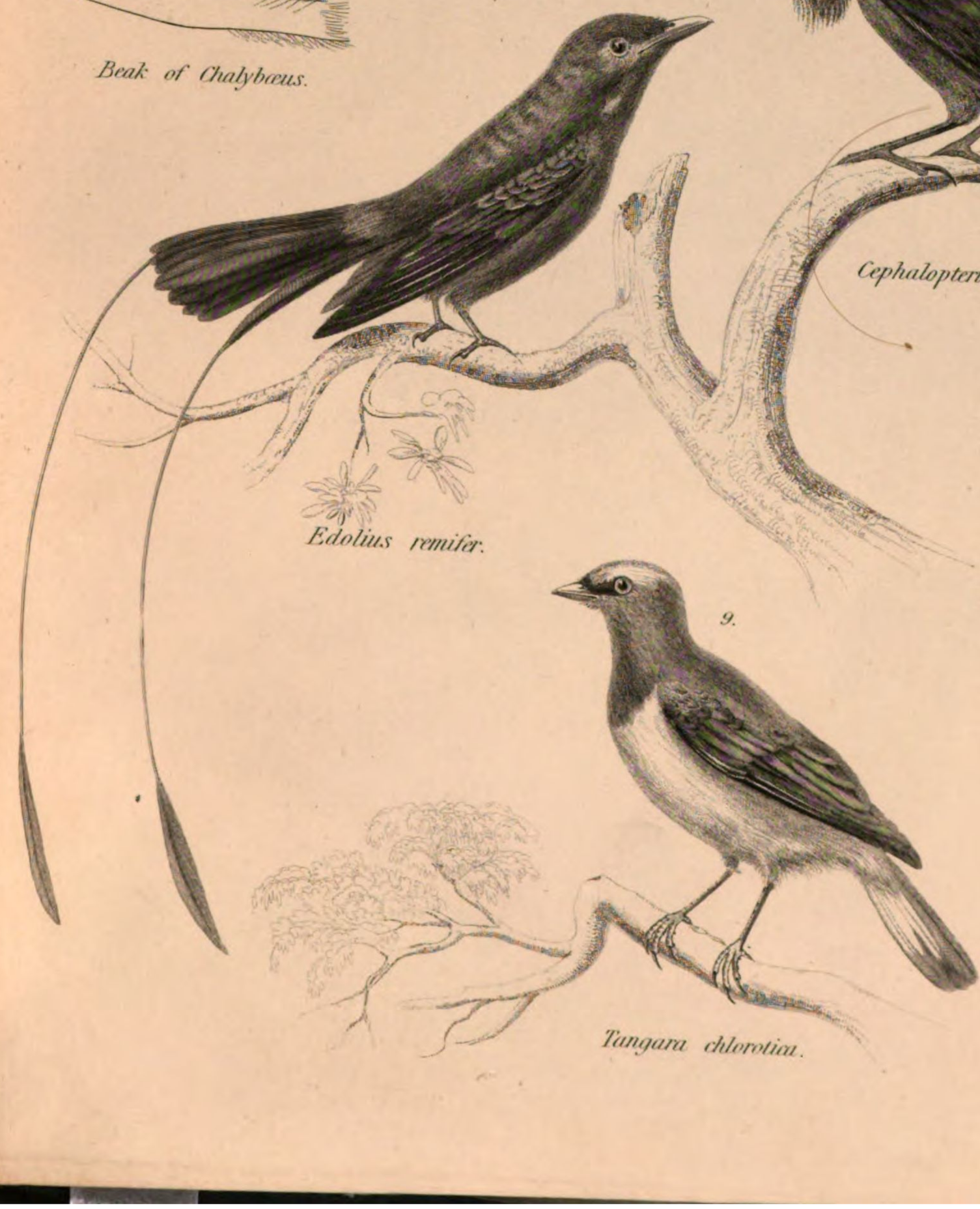


Beak of Tyrannus.

6.

Beak of Chalybæus.

7.



Cephalopterus ornatus.

8.

Head of Gymnocephalus.

Edolius remifer.

9.

Tangara chlorotica.

10.

Casmarhynchus variegatus.

Geo. Aikman, Sculpt

1.

Myothera superciliosa.

2.

Ramphocelus Jacapa.

3.

Eulabes Javanus.

4.

Merula fera.

5.

Pipra parvula.

6.a.

Tor et Caprimulgus.

6.

Pedionomus Olivieri.

7.

Calyptomena viridis.

8.

Corydon Temminckii.

1.

Myothera superciliosa.

2.

Ramphoceles Jacapa.

3.

Eulabes Javanus.

4.

Mœnura lyra.

5.

Pipra pareola.

6, a.

Toe of Caprimulgus.

6.

Podargus Cuvieri.

7.

Calyptomena viridis.

8.

Corydon Temminckii.

Geo. Aikman, Sculp.

Alauda cristata.

Alauda tricolor.

Cassicus cristatus

Synallaxis Tupinieri.

Alauda [illegible]

1.

Alauda cristata.

2.

Garrulus cristatus.

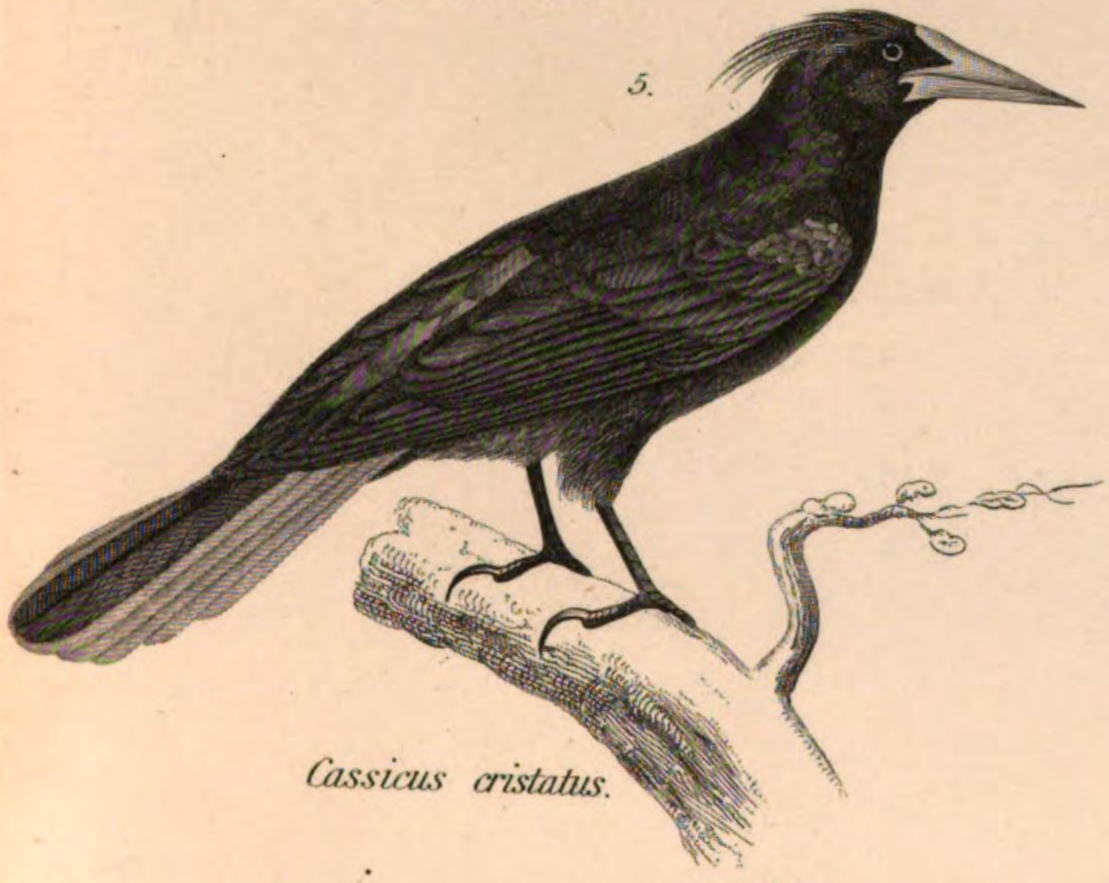
3.

Foot of Colius.

4

Colius leuconotus.

5.



Cassicus cristatus.

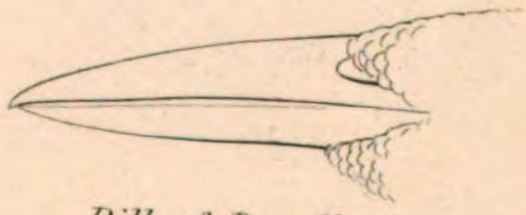
6.

Paradisea apoda.

7.

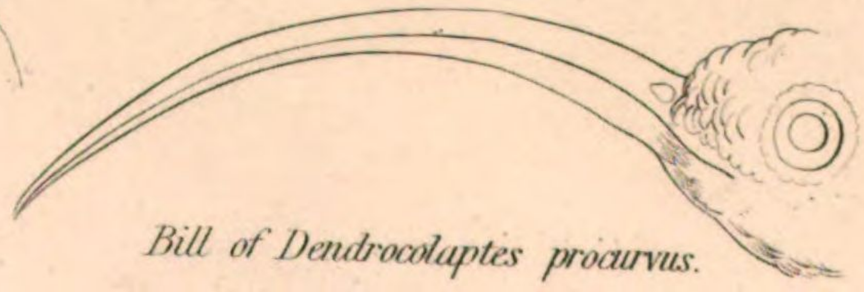
Synallaxis Tupinieri.

8.



Bill of Paradisea.

9.



Bill of Dendrocolaptes procurvus.

Geo. Aikman, Sculp.

Ornismya superba

Trochilus colubris

Ispidina superba

Ispidina picta

Sculp.

1.

Ornismya superba.

2.

Melithreptus vestiarius.

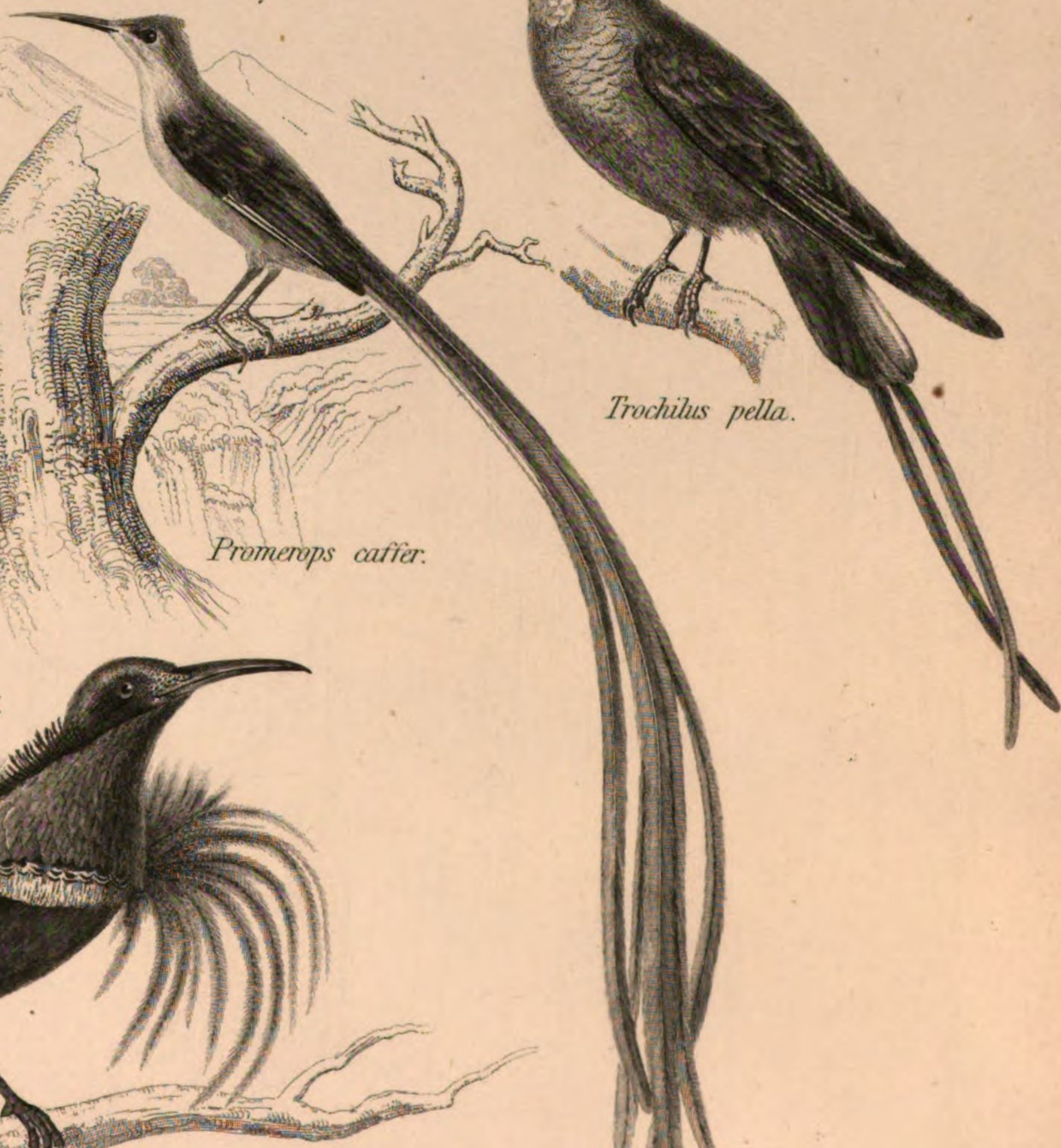
3.

Upupa epops.

4.

Epimachus superbus.

5.



Promerops caffer.

6.

Trochilus pella.

7.

Epimachus magnificus.

Geo. Aikman, Sculpt

Merops apiaster.
Prionites momota.
5.
Ceyx tribrachys.
11.
Ceyx.
Rhinocryptes rhinoceros.
Geo. Aikman. Sculpt.

1.

Foot of Alcedo.

2.

Merops apiaster.

3.

Prionites momota.

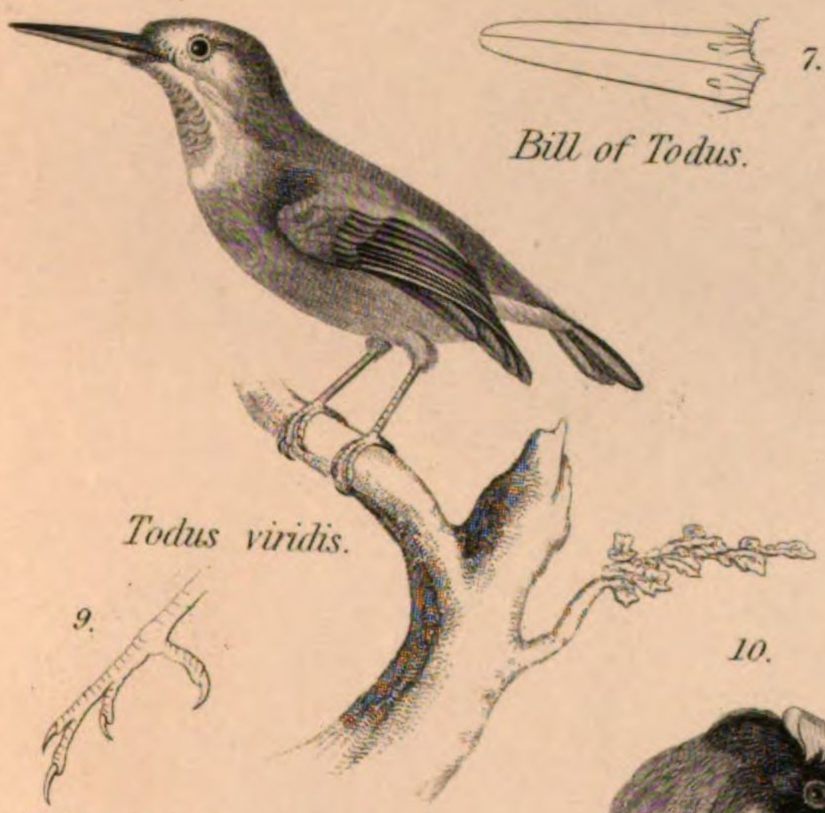
4.

Alcedo cristata.

5.

Ceyx tribrachys.

6.



Todus viridis.

7.

Bill of Todus.

8.

Buceros rhinoceros.

9.

Foot of Todus.

10.

Buceros hydrocorax.

11.

Foot of Ceyx.

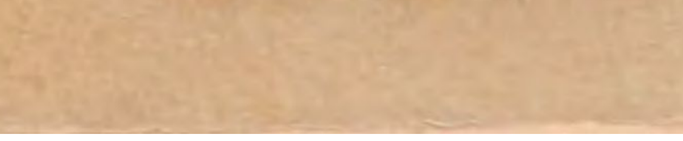
Geo. Aikman, Sculpt

Galbula ruficauda

Crotophaga ani

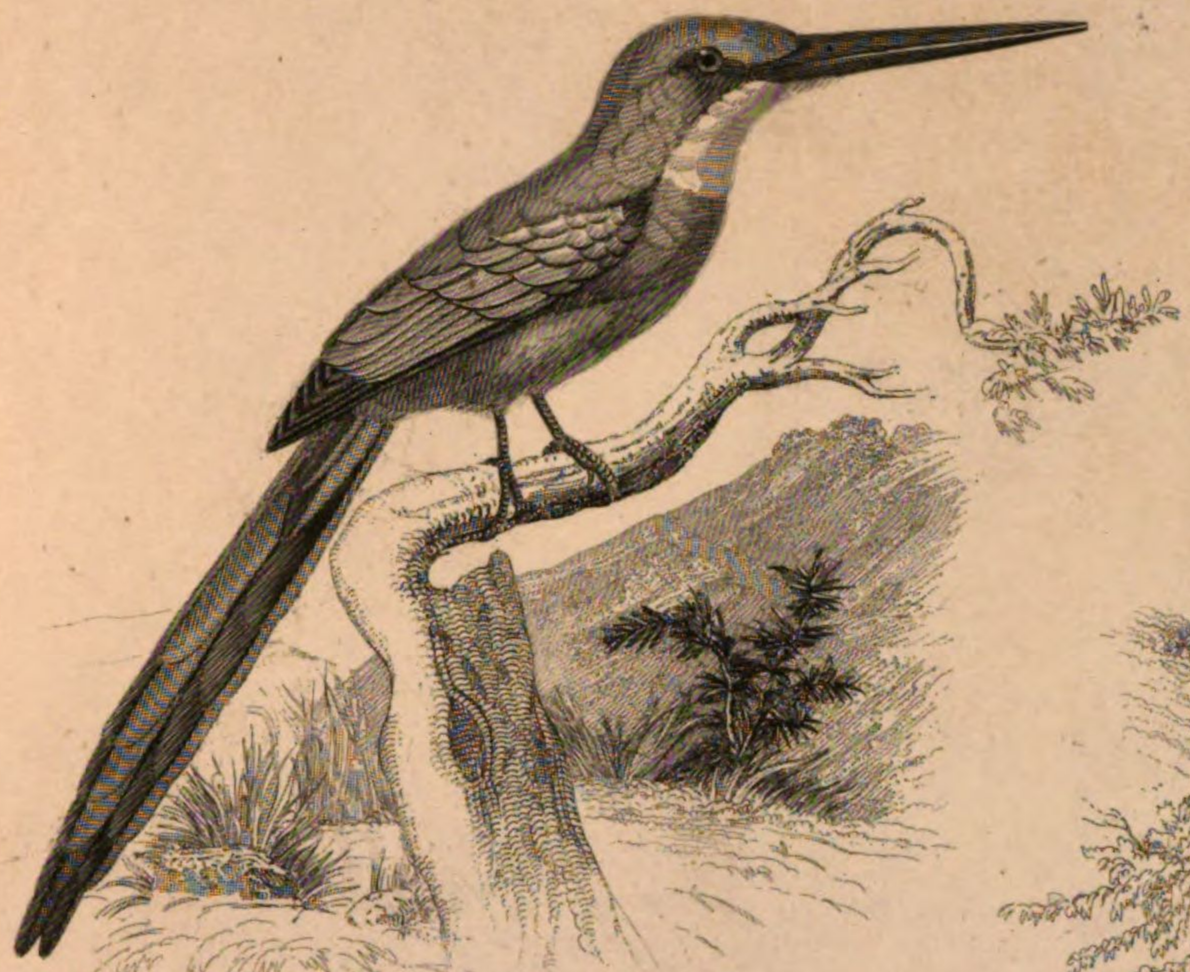
Crotophaga sulcirostris

Ibidorhyncha struthersii



Indicator minor

1.



Galbula ruficauda.

2.

Jacamerops grandis.

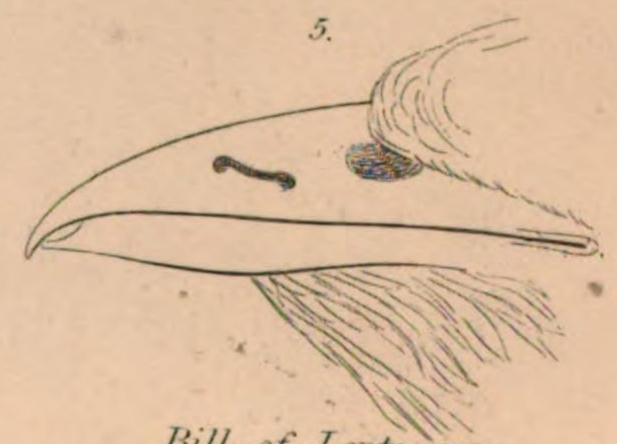
3.

Foot of Picoides.

4.

Coccyzus cristatus.

5.



Bill of Leptosomus.

6.

Indicator minor.

7.

Monasa leucops.

Geo. Allman. Sculpt

1.

Phenicophaus superciliosus.

2.

3.

Pogonias major.

Scythrops Novæ Hollandiæ.

4.

Tragon viridis.

5.

Crotophaga ani.

6.

Ramphastos toco.

7.

Pteroglossus aracari.

1.

Phœnicophœus superciliosus.

2.

3.

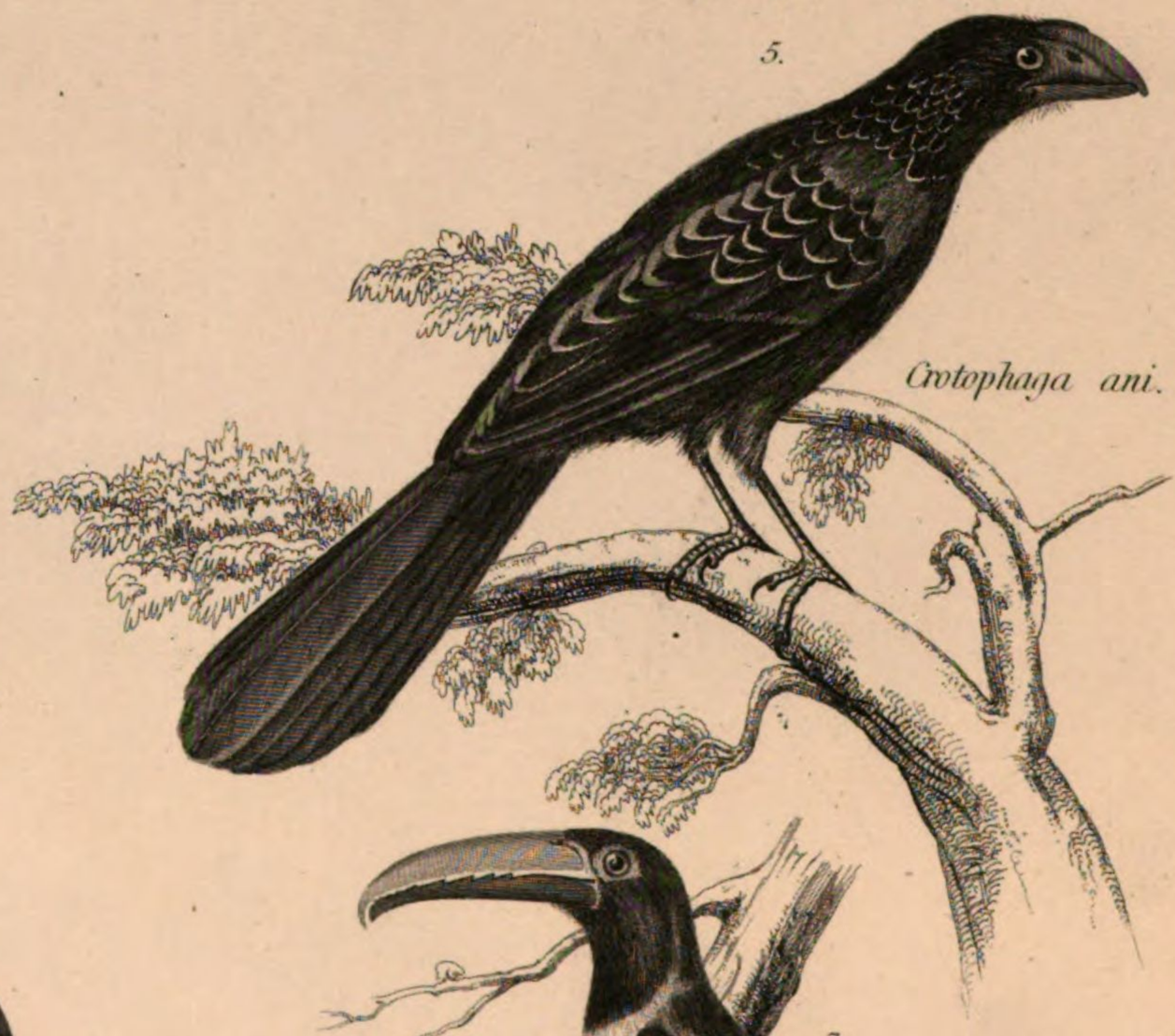
Pogonias major.

Scythrops Novæ Hollandiæ.

4.

Trogon viridis.

5.



Crotophaga ani.

6.

Ramphastos toco.

7.

Pteroglossus aracari.

Geo. Atkinson, Sculp!

Macrocercus tricolor

Calyptorhynchus Banksii

Plyctolophus galeritus

Head of Microglossum

Microglossum aterrimum

Prezophorus torrestris

Corythaix Musicus

Musophaga gigantea

Geo. Aikman, Publ.

1.

Macrocercus tricolor.

2.

Calyptorhynchus Banksii.

3.

Plyctolophus galeritus.

4.

Pezophorus terrestris.

5.

Head of Microglossum.

6.

Microglossum aterrimum.

7.

Corythaix Paulina.

8.

Musophaga gigantea.

1.

Crax rubra.

2.

Head of Ourax pauxi.

3.

Gallus Bankiva, Male.

3, a.

Gallus Bankiva, Female.

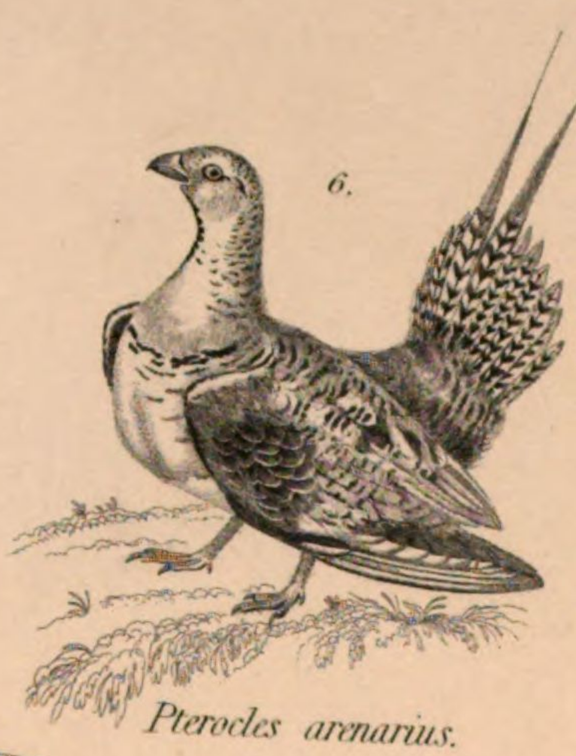
4.

Tragopan Satyrus.

5.

Cryptonyx coronatus.

6.



Pterocles arenarius.

7.

Ortyx Californica.

8.

Tinamus rufescens.

9.

Ortygis pugnax.

Geo. Aikman, Sculpt

1

Lophyrus cristatus.

2

Casuarius galeatus

3

Vinago cruentata

4

Otis Arabs

5

Struthio cumelus

6

Plumes of the Emeu

7

Dicholophus cristatus

8

Mesoenas eremitus

9

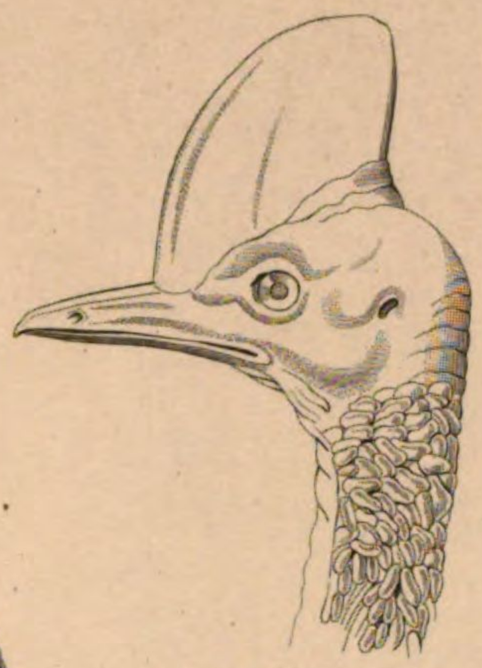
Anthropoides pavonina

Scalp

1.

Loplyrus coronatus.

2.



Casuarius galeatus.

3.

Vinago aromatica.

4.

Otis Arabs.

Struthio camelus.

5.

Plumes of the Emeu.

6.

7.

Psophia crepitans.

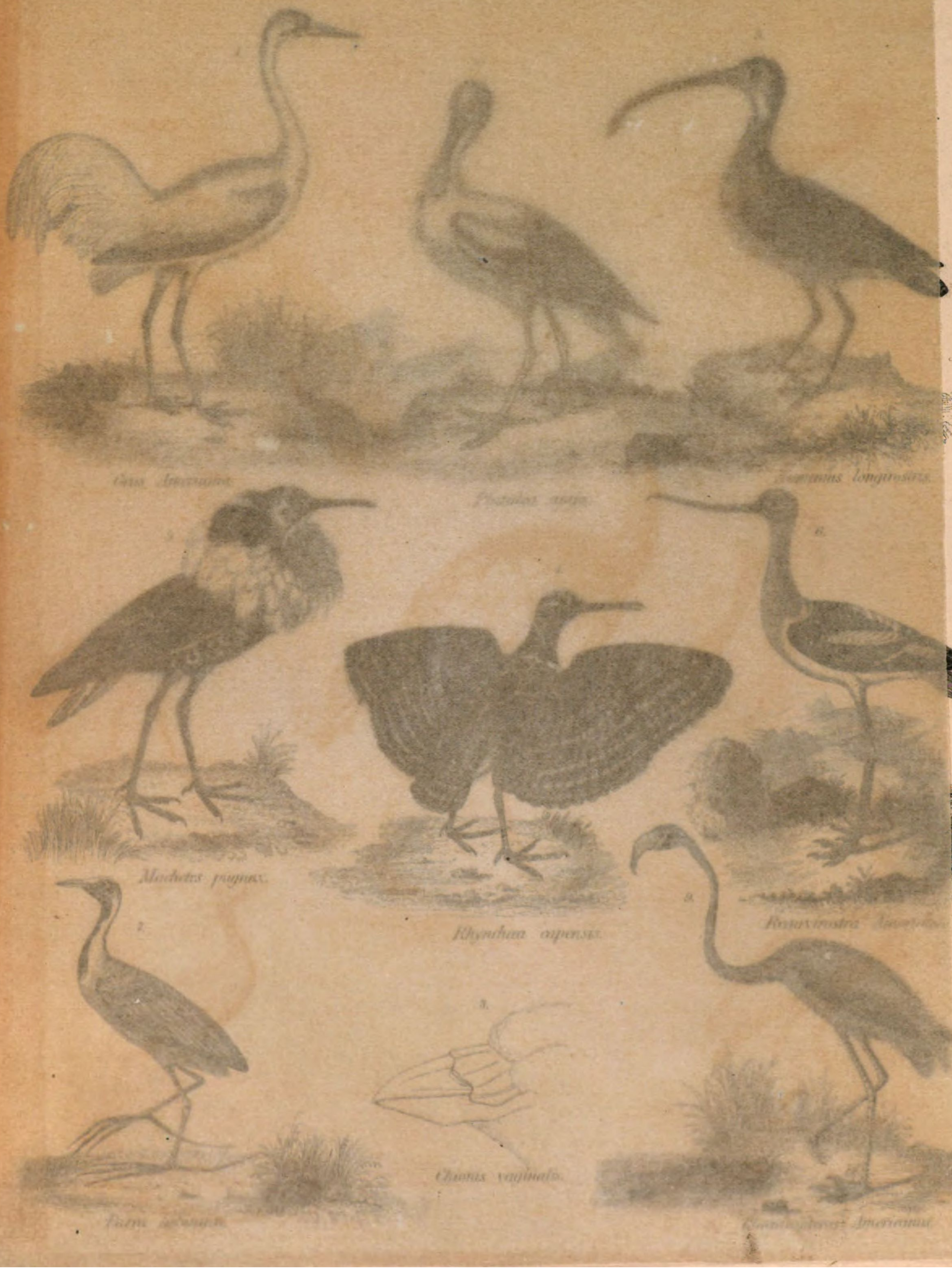
8.

Microdactylus cristatus.

9.

Anthropoides pavonina.

Geo. Aikman, Sculp.t


Ibis Americana
Numenius longirostris
Platalea ajaja
Machetes pugnax
Rhynchaea capensis
Recurvirostra Americana
Tringa Canutus
Chionis vaginalis
Grus Americana

1.

2.

3.

Grus Americana.

Platalea ajaja.

Numenius longirostris.

5.

4.

6.

Machetes pugnax.

Rhynchæa capensis.

Recurvirostra Americana.

7.

9.

8.

Parra albinuca.

Chionis vaginalis.

Phœnicopterus Americanus.

Geo. Aikman, Sculp!

Bull et Barraud

Dendrocygna arborea.

Rhynchops nigra.

Pelecanus onocrotalus.

Geo. Aikman Sculp.

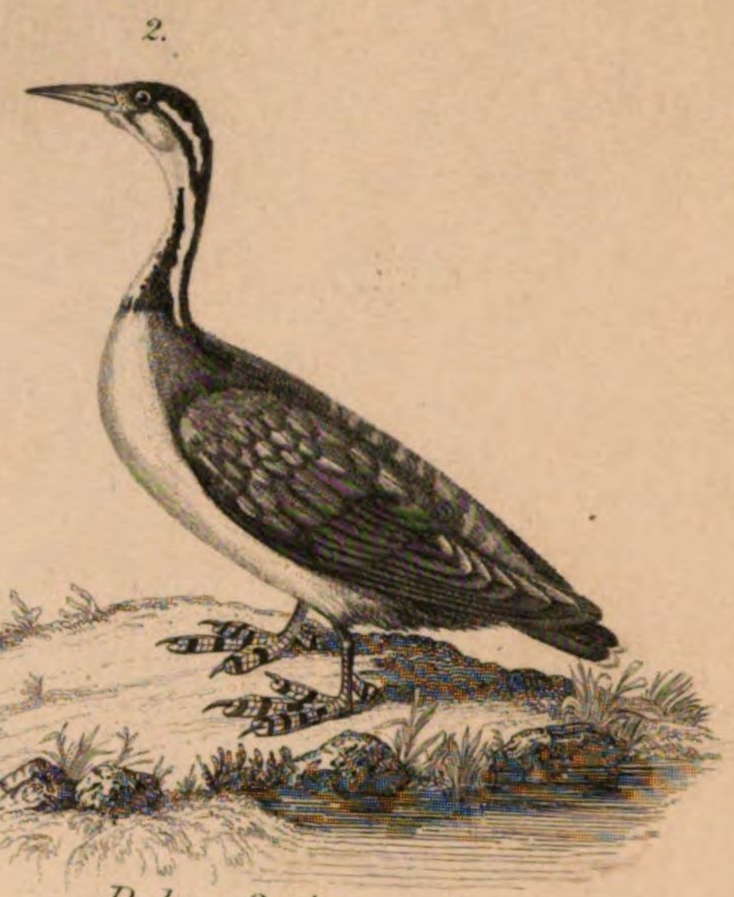
1.

Podiceps cornutus.

4.

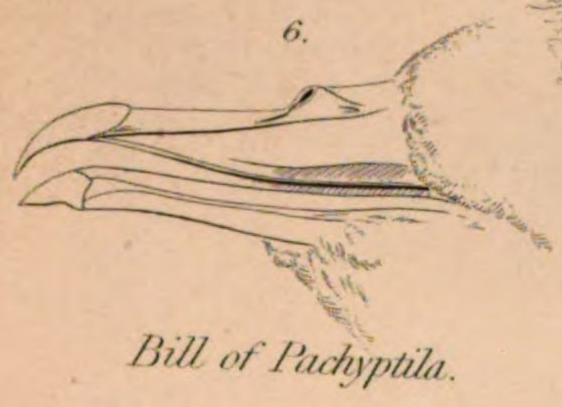
Aptenodytes patagonica.

2.



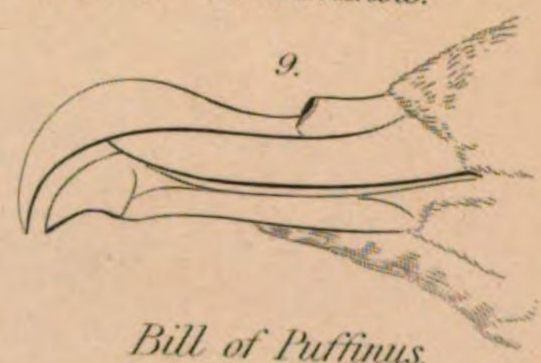
Podoa Surinamensis.

6.



Bill of Pachyptila.

9.



Bill of Puffinus.

3. a.

*Gen. Sphenisc*us.

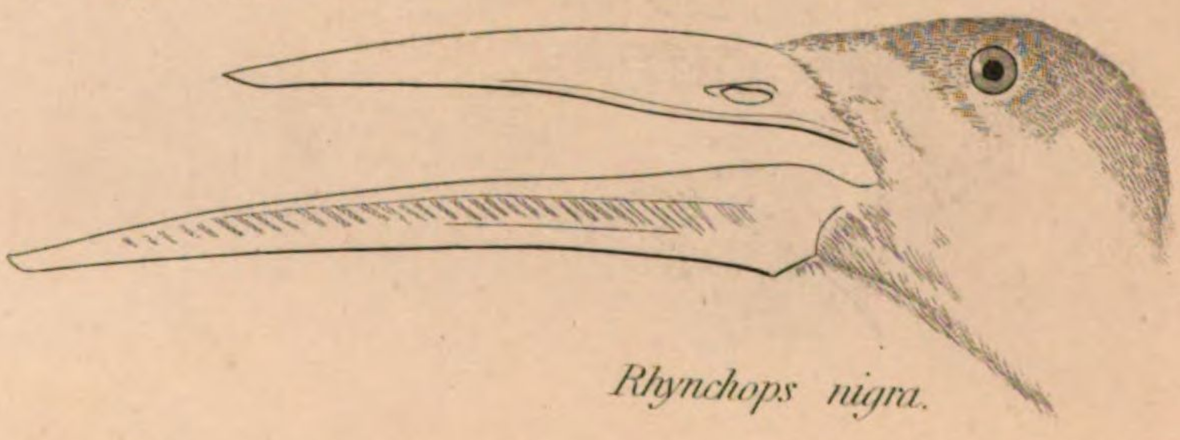
3. b.

Gen. Chrysocoma.

5.

Procellaria pelagica.

7.

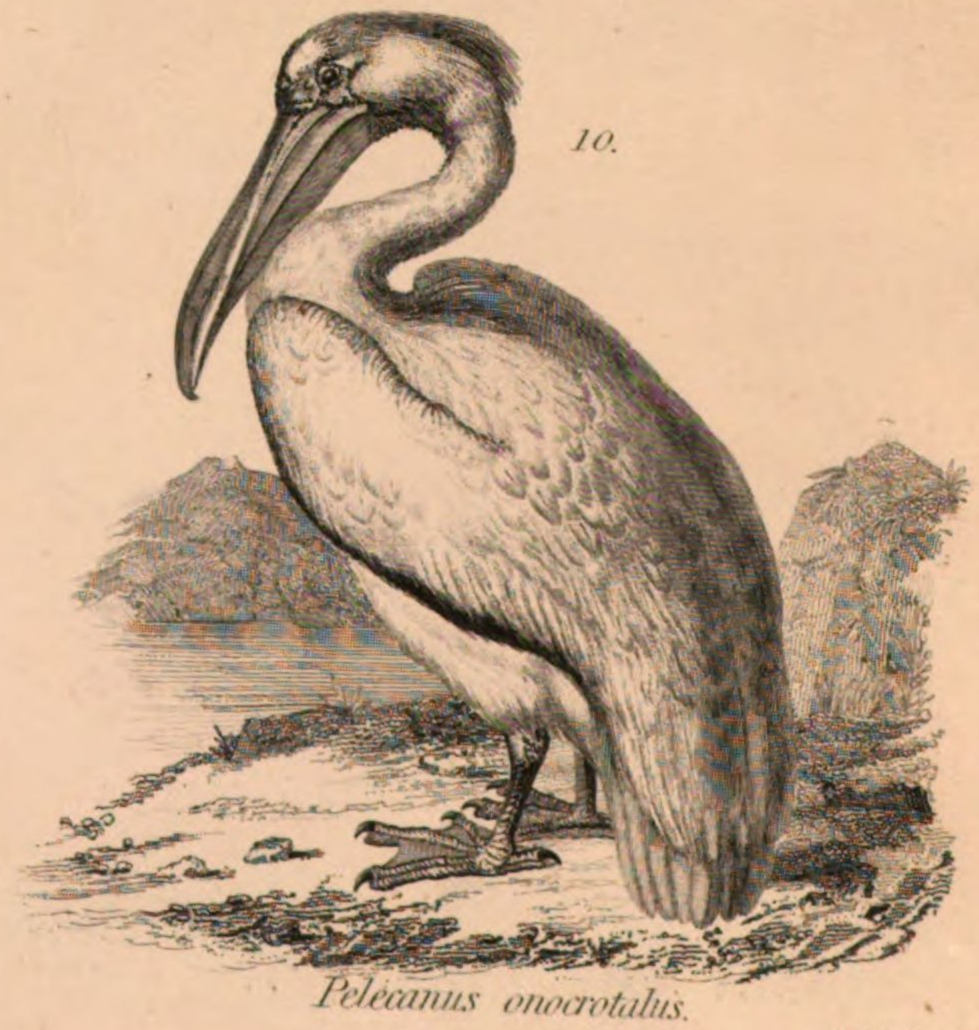


Rhynchops nigra.

8.

Larus marinus.

10.



Pelecanus onocrotalus.

Geo. Aikman Sculpt

Anas sponsa.

Geo. Aikman, Sculpt

1.

Plotus melanogaster.

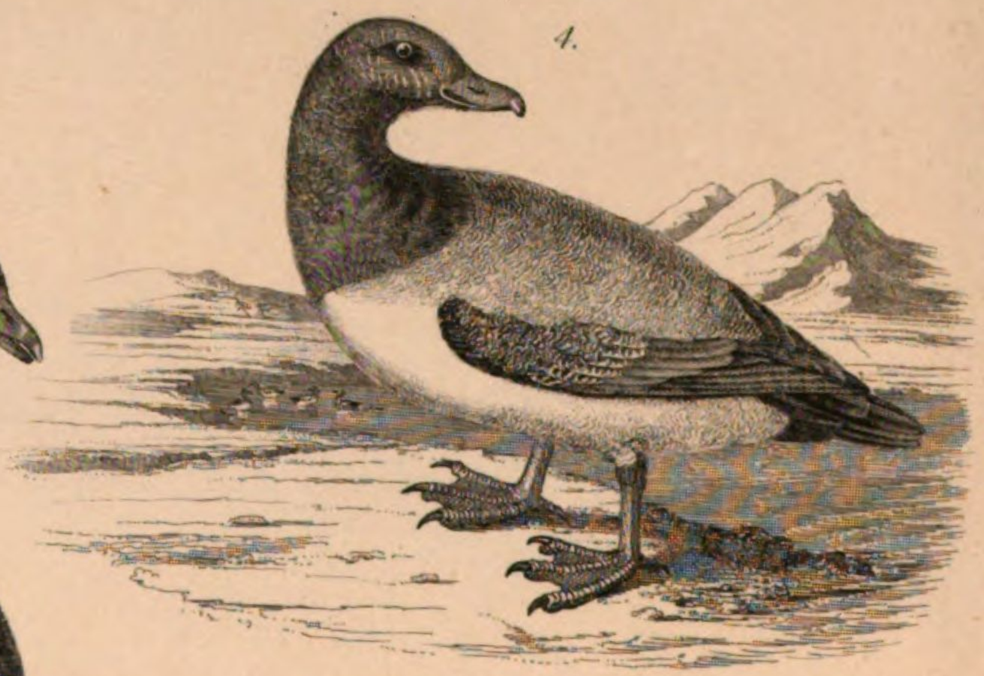
2.

Cereopsis Novæ-Hollandiæ.

3.

Clangula histrionica.

4.

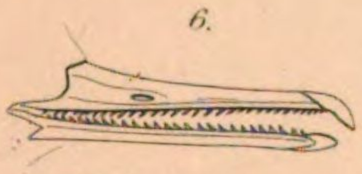


Fuligula Valisnieri.

5.

Cygnus atratus.

6.

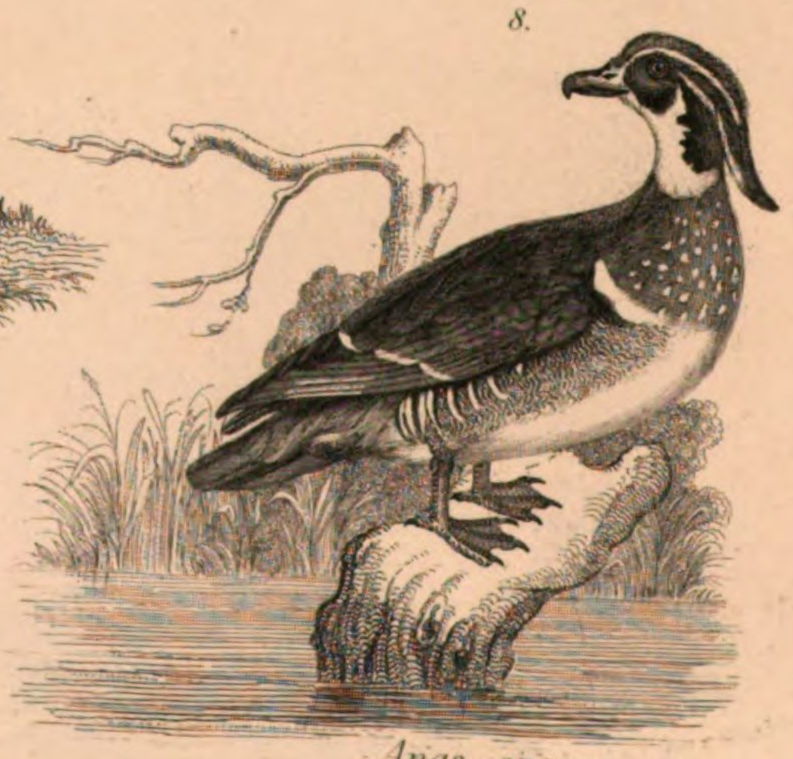


Bill of Mergus.

7.

Mergus cucullatus.

8.



Anas sponsa.

Geo. Aikman, Sculpt.

PALESTINE

Scale of English Miles.
5 10 20 30 40 50

35 36 37

34 33

Khan Bered Orthosia · El Kamkein · El Bakar · Belmont · Deir Natour · Enfah Trieris · Ras el Shakaa · Batroun Botrys · Amsheer · Djebail Byblos · Alcobile El Bouar · Ghadar Jouni · Zouk Mesaylah · Nahr el Kelb Lycus R. · Antoun Elias · Beirout Berytus · Ras el Beirout · Boorjee Khordlee · Jee Porphyrium · Nebby Yunes · Saida Sidon · Ruins Ad Nonum · Ain el Kantara · Sarfend Sarepta · R. Abu el Aswad · Khan · Soor Tyrus · Ras el Ain Palæ Tyrus · Ras el Abiad or C. Blanco · Ain el Scandaroni Alexandroschene · Nakhora · Burge Msherify · Zib Achzib · Bay of Acre · Haypha Hepha · C. Carmel · Tooly · Menny · Medoowe · TRIPOLI Tripolis · Callamona · Kulleah · Kar Akkar · Amyoun · Kanobin · Aabeidat · Hamize · Nahr Ibrahim Adonis R. · Nahr Muhamutain · Deir Aouan · Mtein · Zouk Mykayl · Mar Hanna · Dibbiye · Nahr el Salib or Beirout R. · Hadded · Mar Hanna · Deir el Kammar · Larouk · Platanon · Mar Elias · Keriya · Meshmoush · Abbosh · Nabathie · Nsar · Leontes · Taybe · Kankale · Hebron · Ain Booboo · Cana · Maron · Aiatch · Burge · Kafarletick · Alma · Tarshiha · Geskaulah · Sasah · Szaffad · Khan Djob Yousef · El Mufshoor · Mugar · ACRE Ptolemais · R. Naamany · Plain of Acre · Hattin · Sheikhamer · Magdal Magdala · Tell el Sheik · Nahr el Berid · Nahr Akkar · Akkar Raphanea · Eden · Bshirrai · Hosrun · Tamurin · Laldouk · Afka Aphaka · L. Liemoun · Deir el Akhmar · BAALBEC Heliopolis · Tel Hezin · Nieha · Rafka · Shaem · Abla · Zahle · Medjdel · Sonire · Sultan Yacoub · Kor Aveh · Deneibe · Rasheia · Nimrod's Tomb · Hasheya · Beit el Djanne or Ho. of Paradise · Jordan Fons · Laish or Cæsarea · Gesher · Tell Kadhi · Bahr el Hoole L. Samachonitis · Yallahe · Noworan · Tel el Khanzir · Jacobs Br. · Tallamihe Chorazin or Bethsaida · Khastein · El Aal · Dalmanatha · Feik · Nahr el Kebir · Akkar el Aatik · Nahr Kadisha · Nahr el Berde · Abana R. · Bourkaish · Zaky · Sasa · Karcymbe Khan · Kanneytra · Canatha · Onhul · Kasem · Om el Mezabel · Nowa · Shemskein · W. Air · Draa Adraa · El Mezareib · Annette · Dsakyr · Sharian · Kheratha · Dilly · Tseil · Wady Rokad · Wady Harair · Wady Aadlan · Water of Lebanon · Lake of Tiberias or Sea of Galilee or Genesareth · Jordan R. · Katani · Homs Emesa · Homs or Kadez L. · Shensher · Shemsyn · Hassyah · Khan Seteel · El Burge · Ain en Aalak · Gaseah · R. Aasy Orontes · Dair Mousa · El Ras Orontis Fons · Carah Carræ · Deir Aatyah · Nebk · Yabrood Jabruda · Zurgaia · Djob Aadyn · Maloola · Zerdeni · Saydn yah Saana · Marra · Eslarag · Ktifa · Eldjdile · Tel wy Menin · Kousair · Nebi Abel Abila Lysanie · Dummar · Doumas · Salchie · Katana · Zebedani · Artous · El Sherafie · Bahr el Mardj · El Kessoue · Khan Denoun · Khiara · Soghba · El Merdjan · Aamoud Erzoubh · Om el Kezdar · Ghabarib · Didy · Massana · Phœnessus · Szanamein · Essowara · El Hazzan · Tebne · Mehadje · Dsakyr · El Khelkhele · El Ledja · Redheimy · Bezeine · Ezra Zarava · Om Harereim · Heitt · Essammera · Om Ezzeitoun · Bousser · Aaliere · Shobba · Ain Keratha · Doubba · Tetkha · Nahita · Ain Mezra · Salcim · Tel Um Zebaib · Gebel Haouran · Souedia · Wady el Medan · Ain Tabegha Bethsaida · Capernaum · Tell Hoom · Khan Minyeh · Ain el Tineh · Ain el Bukar · Tell el Oreimeh · Tell el Ashary · Tell el Assur · Tell el Kady · Tell el Hamy

Acre
Haypha
Hepha
C. Carmel
R. Naamany
Plain of
Shefthammer
Hattin
Migdal Mandala
Khastein
El Aal
Dalmanatha
Wady
Wady Hareir
Shemskein
W. Air
Draa Adraa
Bousser
Aahere
Ain Keratha
Nahita
Ain Mezra
Doubba
Saleim
Shobba
Tefkha
Tel Um Zebeib

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HONI SOIT QUI MAL Y PENSE
DIEU ET MON DROIT

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MDZ Münchener DigitalisierungsZentrum Digitale Bibliothek

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Edinburgh (1842)
4 Enc. 7 c-16,2
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